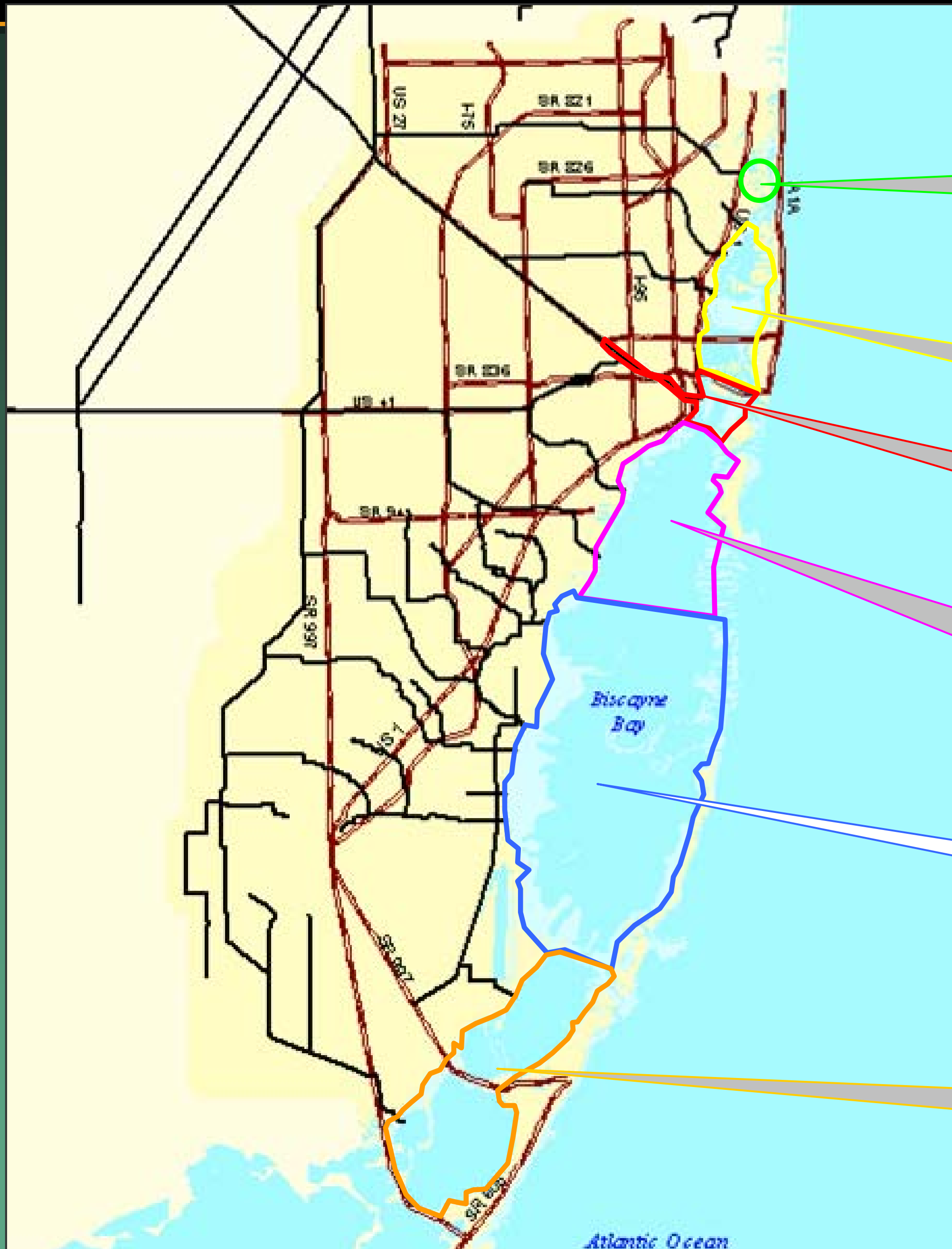
Biscayne Bay
Minimum Flows and Levels
(MFLs)

August 25, 2004

WRAC Issues Subteam

MFL Regions of Biscayne Bay



- Snake Creek/Oleta River
- North
- Miami River
- North Central
- South Central
- South

1. What is the “baseline”? (Item 1)

Baseline:

- a set of critical observations or data used for comparison or a control;
- a starting point

For establishment of MFL criteria, it is the basis of comparison, i.e. a known condition of the resource used as a reference point to determine significant harm.

Terminology Used in CERP

- *Baseline Condition:* Estimated present condition (status and trends) of the resource, generally based on recent or ongoing data collection.
- *Reference Condition:* A point (generally historical) when the condition of the resource was known or estimated and that represents an acceptable quality.
- *Endpoint:* A desired, expected or observed outcome, condition or state that occurs when management actions have been completed and the ecosystem has reached equilibrium with the resulting modified environment.

Considerations and Exclusions

What considerations or exclusions relate to developing MFLs for Biscayne Bay?

- Considerations. Section 373.0421(1)(a), F.S., indicates that Districts shall *consider* changes and structural alterations when setting MFLs.
- Exclusions. In addition, as defined in Section 373.0421(1)(b), F.S., allowances can be made for loss of historic functions when water bodies no longer serve their historical function and recovery to historical conditions may not be feasible.

The extent to which considerations or exclusions are applied for Biscayne Bay needs to be determined.

Specific Examples -- Exclusions

- Land Use Changes. Watershed structure and vegetation irreversibly altered by clearing of native species, dredging and filling of wetlands, paving, and altered topography for residential, urban, industrial, and agricultural development.
- Hydrology. Irreversible lowering of water tables and channelization of rivers and streams for drainage and flood protection, altering the timing, distribution and volume of freshwater flow to the Bay.
- Alteration of shoreline habitat. Loss of freshwater wetlands near the bay; increased salinity and changes in extent and species composition of tidal marshes.
- Hydrodynamic Changes. Construction of inlets, dredged channels, and jetties have altered flow patterns and locations, rate and volume of exchange between the Bay and the ocean.

Specific Examples -- Considerations

- District must balance among regional needs for flood control, water supply, and natural systems management.
- Construction and operation of control structures provide some capacity to regulate water levels and the volume, timing, and distribution of freshwater flows to the Bay.
- Natural systems needs must balance among upstream freshwater (inc. Everglades) systems, aquifer protection, coastal wetlands, the estuary and nearshore marine waters.
  - Maintain surface water levels and flows in the watershed
  - Protect of groundwater levels and quality
  - Salinity conditions in the Bay
- Water Quality
  - Maintain productivity in the Bay
  - Avoid eutrophication effects, toxicity or pollution

How the Baseline, Considerations and Exclusions fit into the MFL Process

- Identify water resource function(s) to be protected by a minimum flow or level.
- Compile baseline (*best available*) data and information about condition of resources and effects of reduction in water levels and flows.
- Evaluate functions, current conditions, including "considerations and exclusions" analysis, as a basis for significant harm.
- Establish causal relationships between quantity and timing of freshwater inflow and impacts on resource functions.
- Identify the point or condition at which significant harm occurs.

How Baseline Information is Applied -- Examples

Resource	Baseline	Metrics
Crocodiles	Current population	Numbers and distribution Distribution of size/age classes Sex ratios and condition indices Availability of suitable habitat
Seagrasses	Current species composition and distribution	Overall aerial extent Health/disease status Relative species composition
Small fishes	Increased abundance of key (existing) species relative to current conditions	Overall numbers Species diversity Availability of suitable habitat

How Baseline Information is Applied -- Significant Harm

- Causal relationships that define significant harm:
  - Significant Harm [Ch. 40E–8.021(28)] means the temporary loss of water resource functions, which result from a change in surface or ground water hydrology, that takes more than two years to recover . . . .
- Sample definition for South Central Biscayne Bay:
  - Significant harm occurs when salinities are above *m* ppt and/or freshwater inflows are less than *n* cfs, for more than *p* days, more often than *x* times every *y* years.
- Significant harm may (or may not) be occurring to the resource under baseline conditions.
- Significant harm standard may change in the future as restoration efforts improve baseline conditions.

Recommendations

Considerations and Exclusions

- The concept of an *exclusion,* as described in 373.0421(1)(b)1 F.S. make it impractical to restore portions of Biscayne Bay to a predevelopment condition. The MFLs analysis assumes we will protect/ maintain existing:
  - land uses and development
  - hydrology, structures and control elevations
  - natural communities in the bay and the watershed
  - structural features in the bay –channels, jetties, etc.
- Development of MFL criteria for Biscayne Bay must also take into *consideration* the need to achieve balance among regional flood control, water supply, and natural systems needs.
- Specific exclusions and considerations may change over time as restoration efforts proceed.

Recommendations

Baseline Conditions

- Describe and document land use, water management facilities, hydrology and hydrodynamic features that currently exist.
- Characterize the baseline condition of water resources and natural systems based on the condition of existing resources.
- Establish causal relationships between quantity and timing of freshwater inflow and impacts on resource functions.
- Determine significant harm relative to this baseline condition (significant harm may occur above or below the existing baseline).

Species Screening and Selection (Item 3)

- Staff and consultant spent months researching candidate species
- Followed up on leads from experts
- Screened using criteria
- Continuing to look, but the 8 species span the range of habitats

Short List of Indicator Species	
Scientific Name	Common Name
Halodule wrightii	Shoal grass
Ruppia maritima	Wigeon grass
Callinectes sapidus	Blue crab
Centropomus undecimalis	Common snook
Crassostrea virginica	American oyster
Crocodylus acutus	American crocodile
Farfantepenaeus duorarum	Pink shrimp
Megalops atlanticus	Tarpon

- **42 + potential flora and fauna identified**
- **8 somewhat abundant**

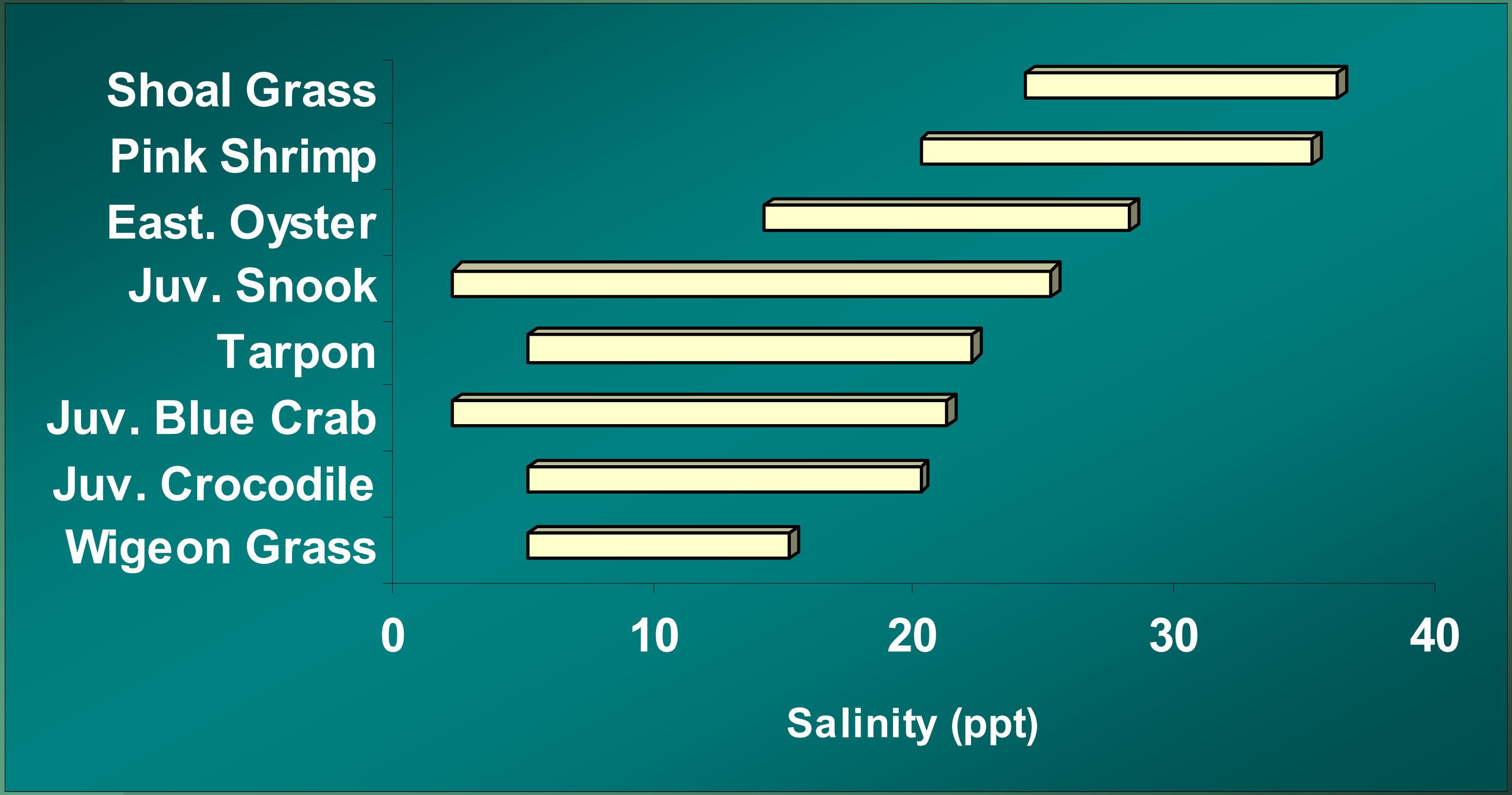
Filtering criteria:

- ***Reside in Biscayne Bay***
- ***Dependent on freshwater input***
- ***Sufficiently Documented***

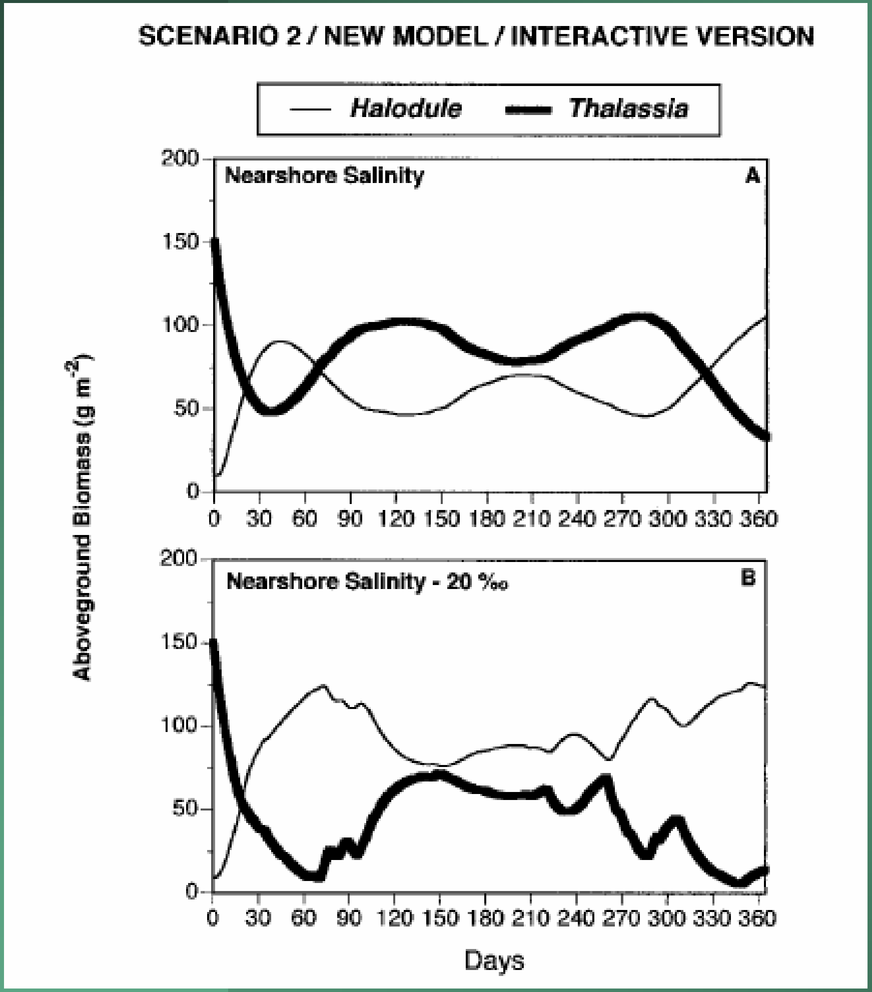
South Central Bay VEC Selection

Species	Health Tied to Salinity	Abundance, Importance	Ease of Monitoring	Effect on Population Viability
Shoal grass	✓	✓	✓	✓
Wigeon grass	✓		✓	✓
Blue crab	✓			✓
Common snook	✓			✓
American oyster	✓		✓	✓
American crocodile	✓		✓	
Pink shrimp	✓	✓		
Tarpon	✓			✓

Approximate Salinity Preference Ranges

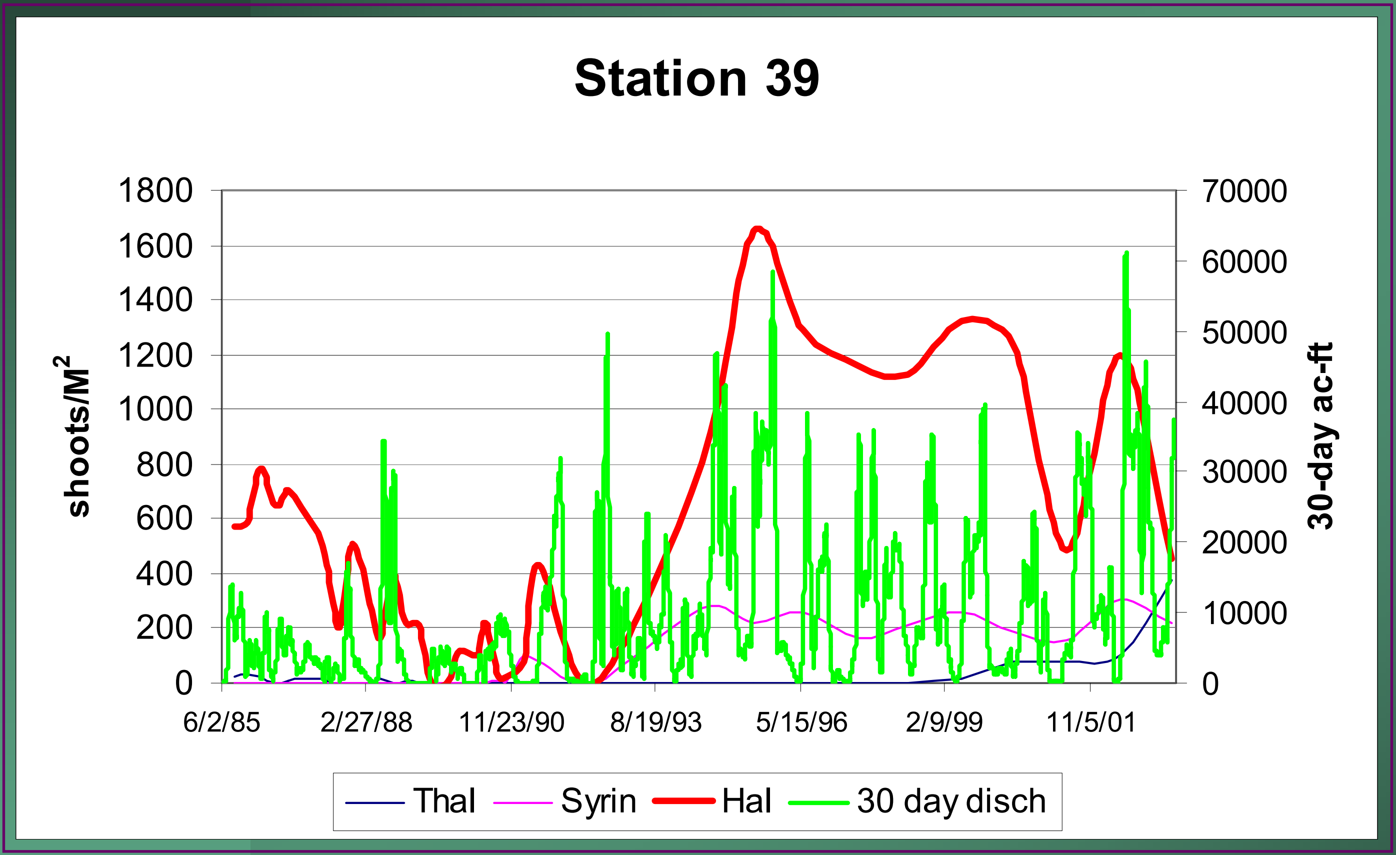


Shoal grass response in study area



- Lirman & Cropper (2003) models
- Shoal grass productivity increases with decreased salinity
- Competes better at lower salinity

Shoal grass response at Black Point



- DERM data collected nearshore
- Shoal grass cover associated with canal flows (C-1)

How Shoal Grass Observations Might Be Used for MFL Monitoring

- Data combined with multiple parameters (biotic and abiotic)
- Change/fluctuations in cover over multiple years
- Data used to improve predictive models for scenario testing

Shoal Grass: Staff's Recommended VEC

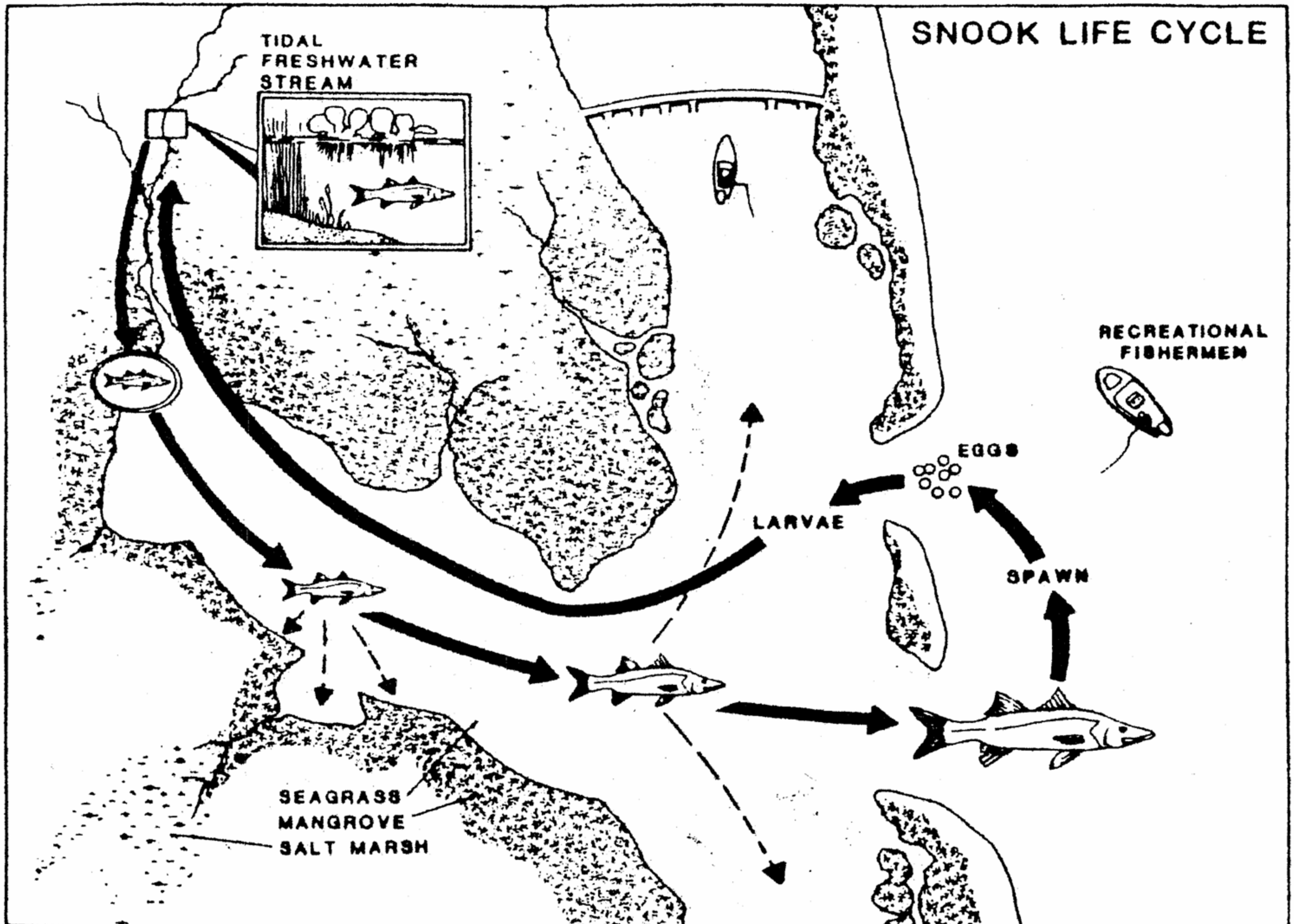
- **Pros:**
  - Has been persistent nearshore 30+ yrs.
  - Important to ecosystem, diversity.
  - Abundance related to freshwater inputs.
  - Can be monitored.
- **Cons:**
  - Coverage responds slowly. Not good for acute conditions.
  - Wide salinity tolerance.
  - Influenced by more than salinity.

What about Fish? (Item 4)

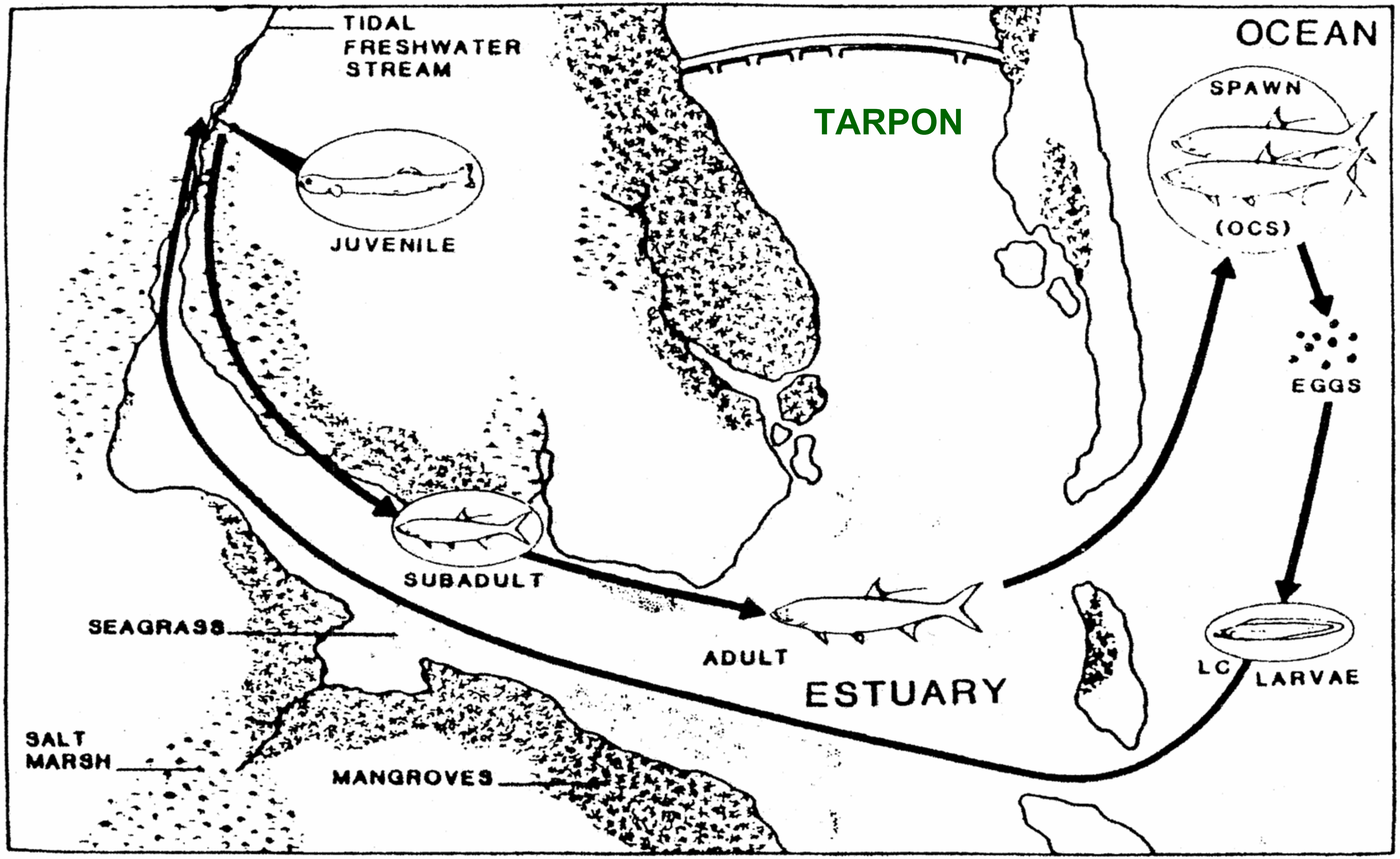
Comparison of western and eastern mangrove shorelines?

Consultant's Assessment

- 14 listed species (Table 4)
- Some information on spotted sea trout
- Snook ranked highest among fish (8th overall)
- Tarpon ranked second (11th overall)


SNOOK LIFE CYCLE
TIDAL FRESHWATER STREAM
RECREATIONAL FISHERMEN
EGGS
LARVAE
SPAWN
SEAGRASS
MANGROVE
SALT MARSH

TARPON



TIDAL FRESHWATER STREAM
OCEAN
SPAWN
(OCS)
JUVENILE
EGGS
SUBADULT
SEAGRASS
ADULT
LC
LARVAE
ESTUARY
SALT MARSH
MANGROVES

Consultant's General Conclusion

- Factors affecting timing/location are unknown
- Factors other than salinity affect recovery
- Protecting primary productivity and lower trophic levels benefits multiple species

"Mangrove Shoreline Fishes of Biscayne Bay, Florida"

- J. Serafy, C. Faunce, J. Lorenz
- Bulletin of Marine Science, 72(1):161-180, 2003
- Diversity and abundance of 9 species
- Common to eastern and western shorelines
- 2 wet/2 dry seasons
- Wet-to-dry within each study area

Mainland Mangrove Shoreline

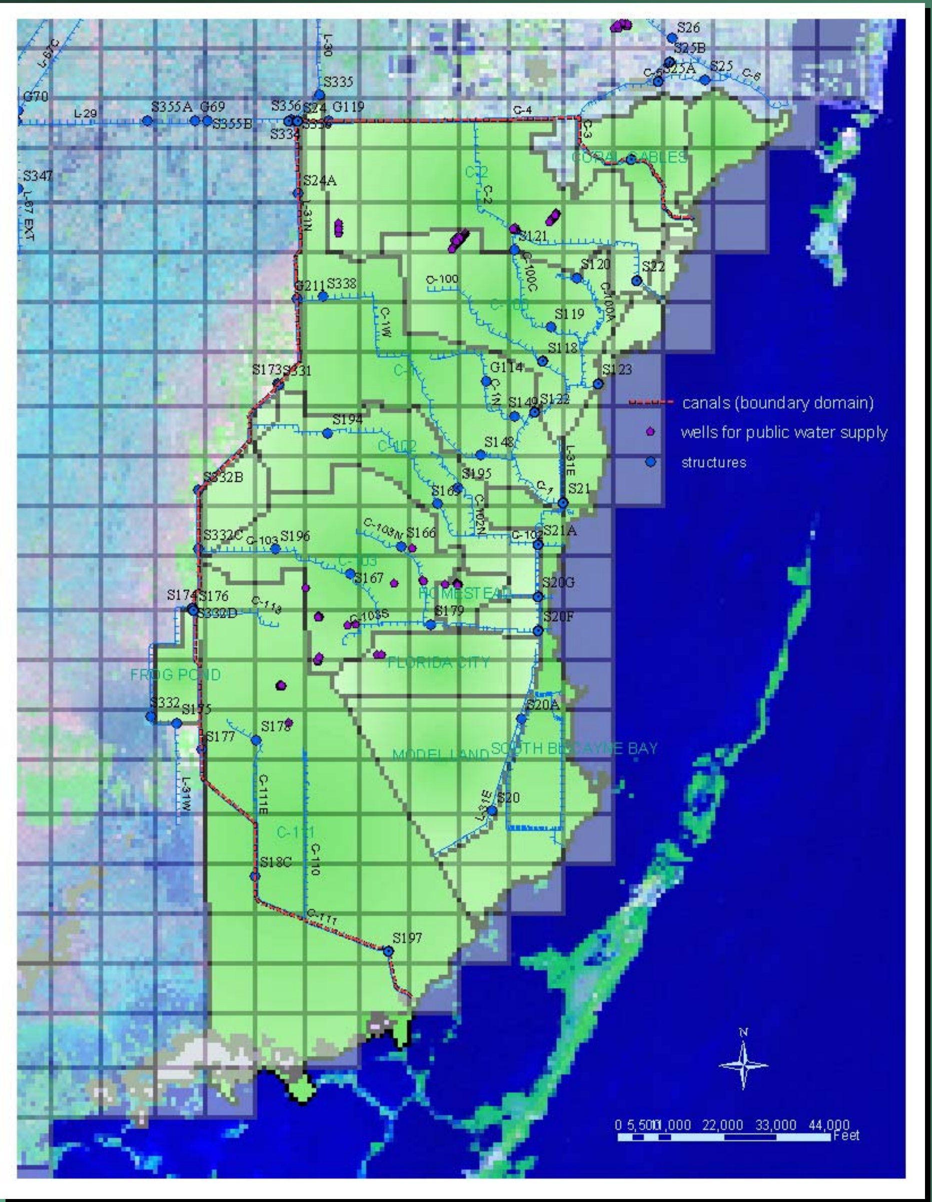
- Lower diversity and density
- Attributed to salinity variation and mean
- Seasonal differences within:
  - Gray snapper (wet season density increase)
  - Goldspotted killifish (dry season density increase)

Conclusions

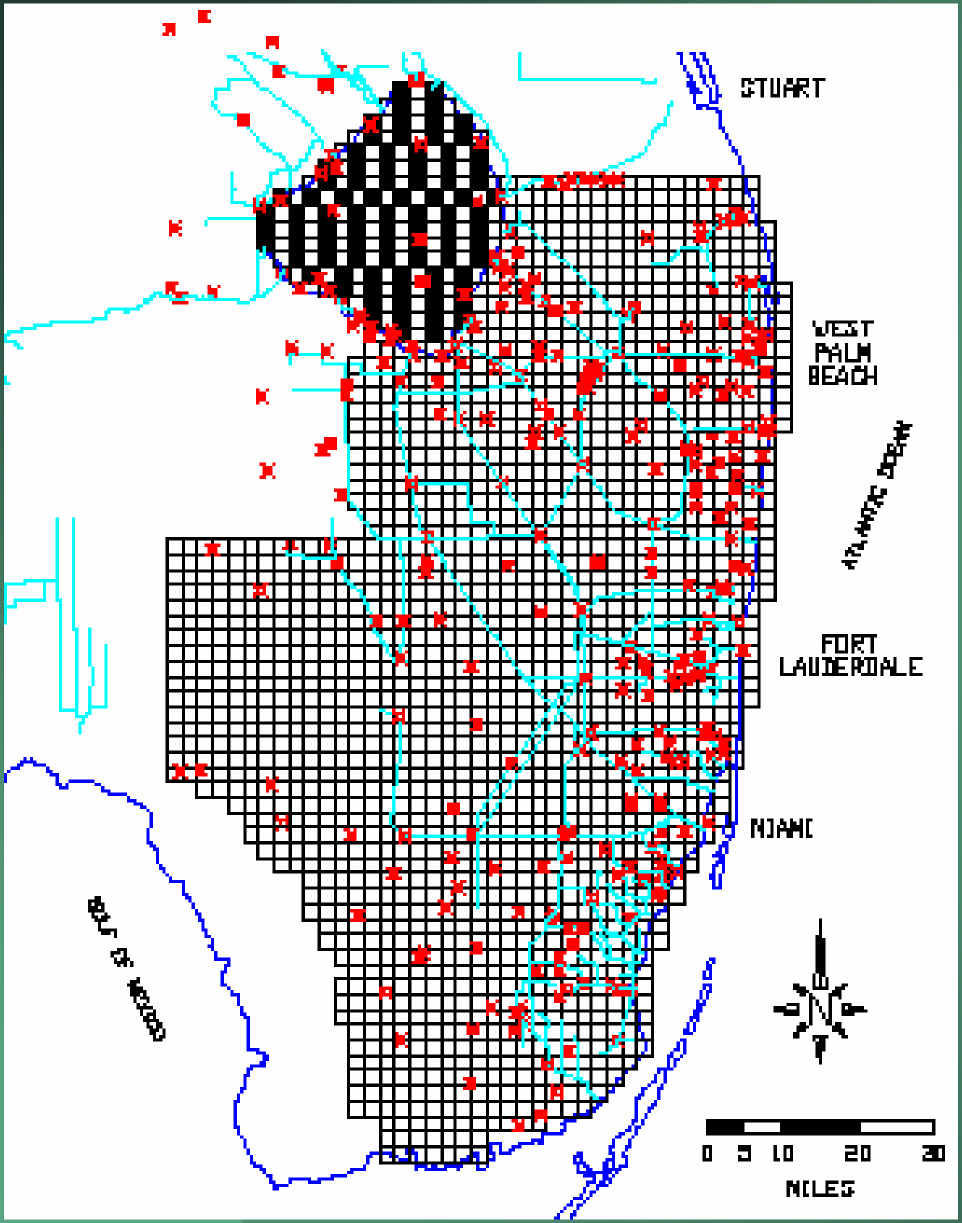
- Fish, in general are not considered good VEC species because they are difficult to monitor, and tend to avoid adverse conditions.
- In this study, only goldspotted killifish exhibited dry season density response in mainland mangroves.
- Goldspotted killifish seem to prefer low-salinity interior marsh areas but tolerate higher salinity conditions during the dry season.

Southern Miami Dade County Watershed (Item 5)

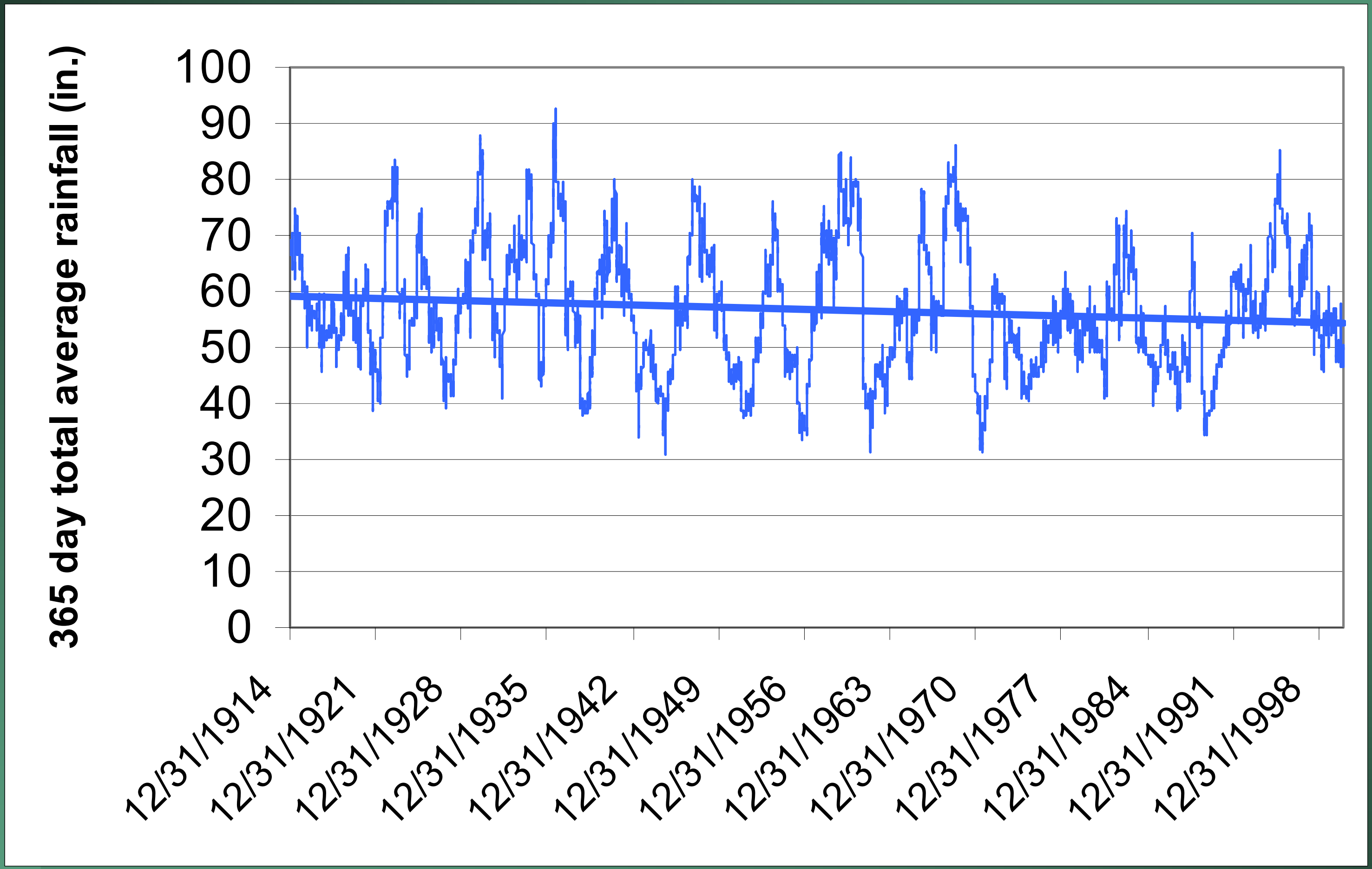
Rainfall and Water Budget Analyses



- Watershed was defined
- Rainfall Analyzed
- Water budgets calculated

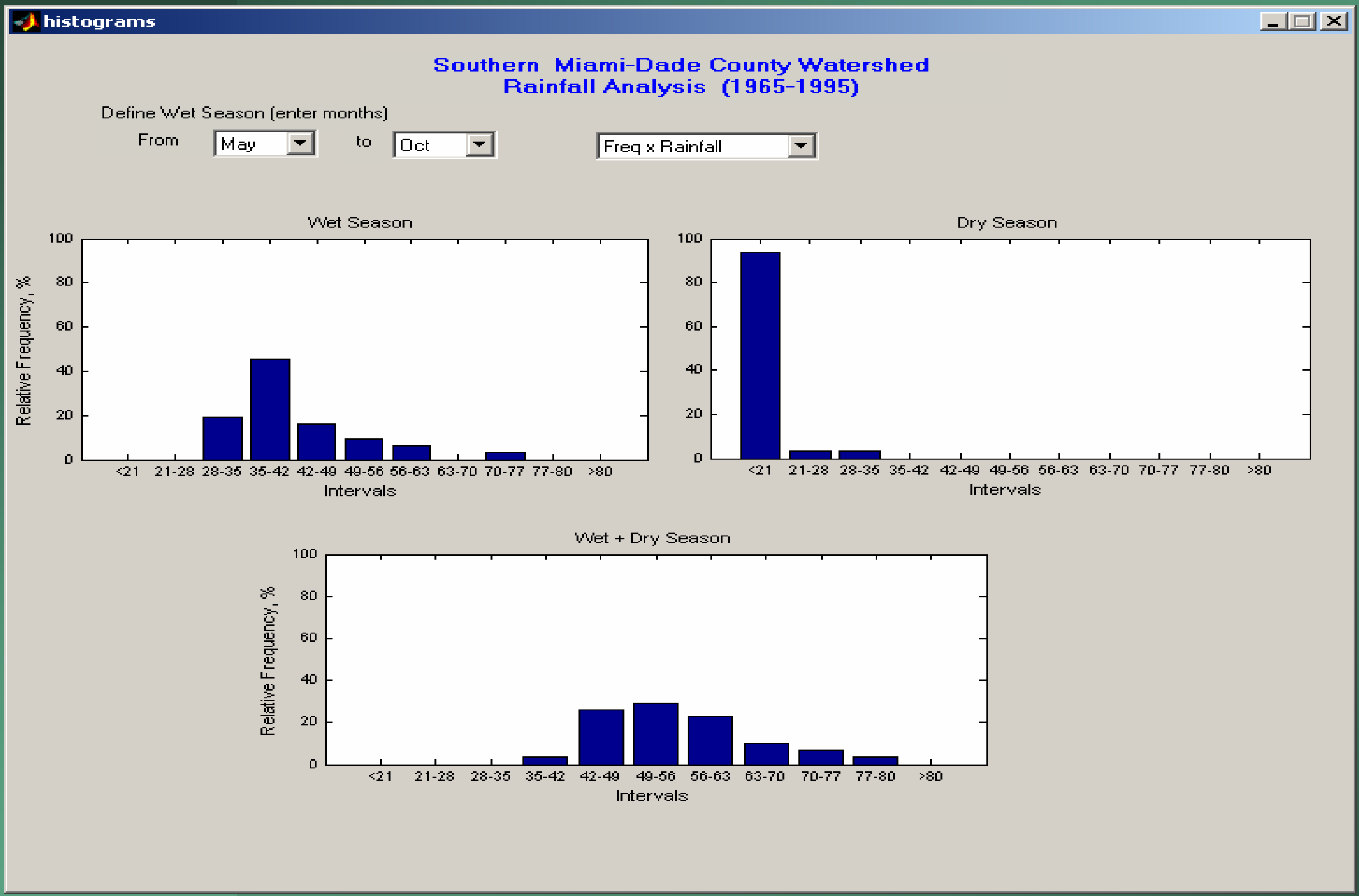


- About 30 rainfall gages within the southern Biscayne Bay watershed
- Some have long term records



Rainfall from 1914 through 2000 has varied and was less during 1965-2000.

Southern Miami Dade County Watershed

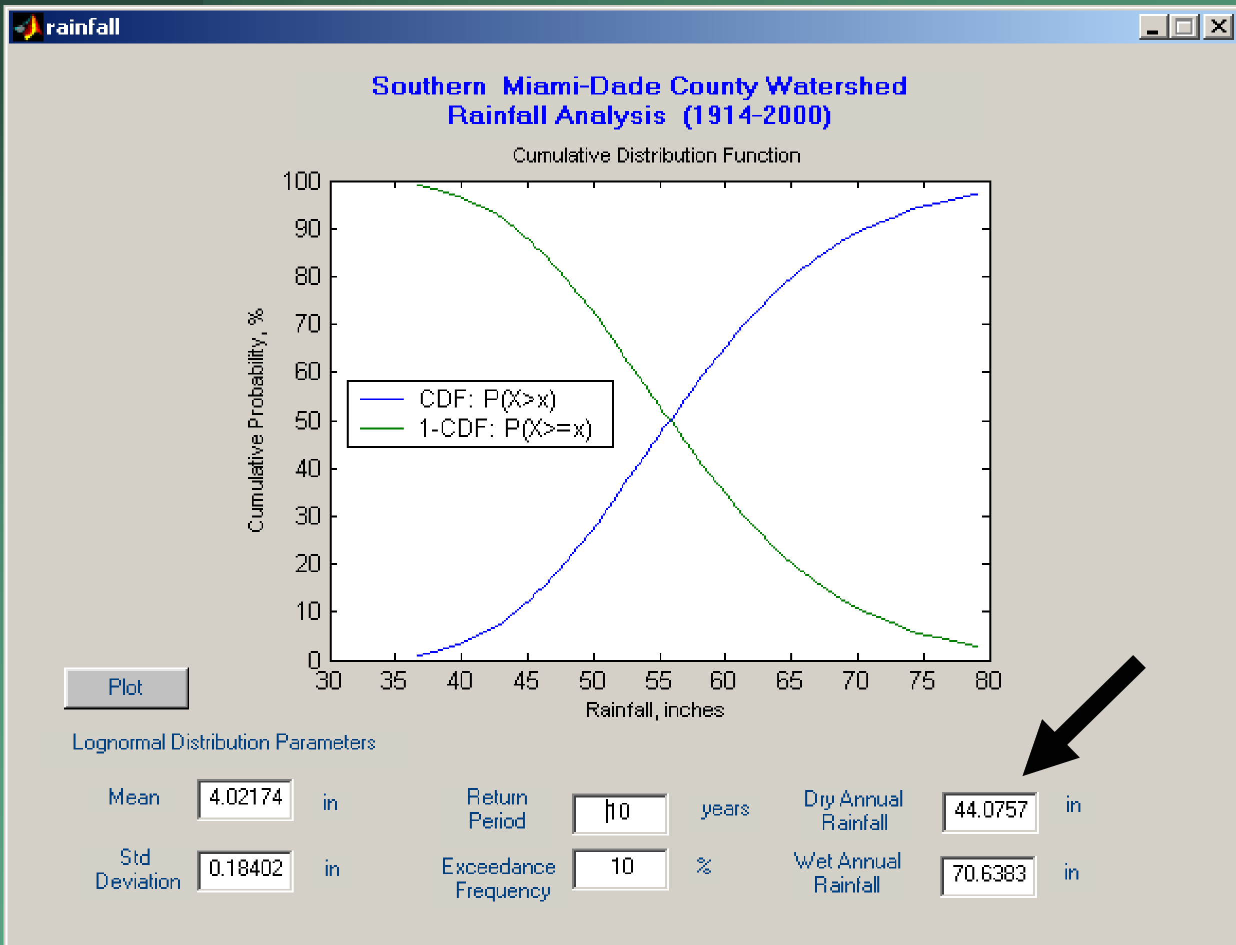


- **Average Annual Rainfall= 56.7 in.**

1 in 10 Dry Rainfall

- A 1-in-10 year drought is a drought of such intensity, that it is expected to have a return frequency of once in 10 years.
- A 1-in-10 year dry rainfall quantity is defined as having a probability of 1/10 in any year.

Southern Miami Dade County Watershed



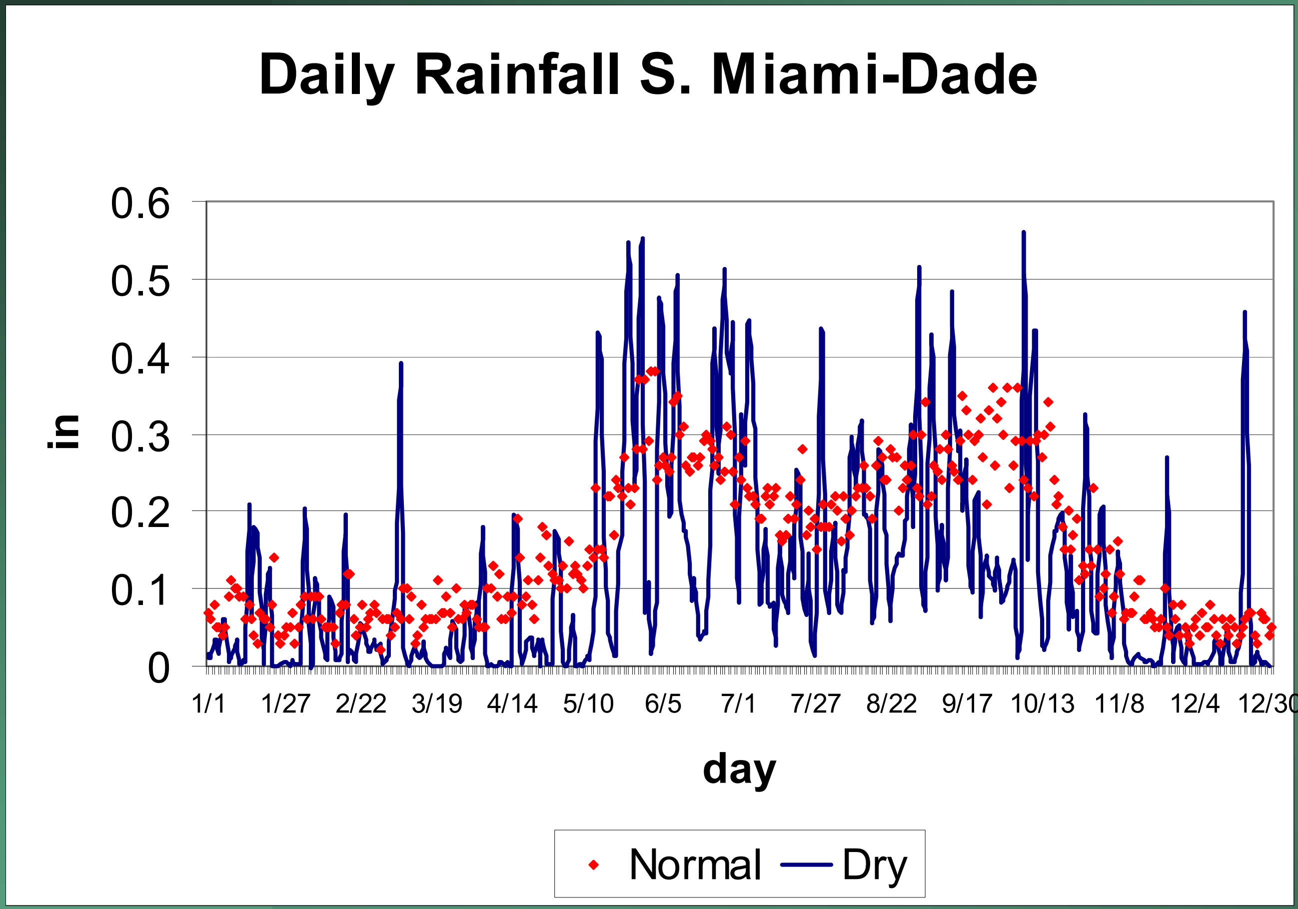
- **1-in-10 Dry Rainfall= 44.08 in. from 1914 to 2000**

Year	Rainfall (in)	% difference from 1-in-10 year dry rainfall
1938	40.1370	-8.94
1944	40.9182	-7.16
1951	38.3746	-12.93
1956	36.6337	-16.88
1961	42.6463	-3.24
1970	43.0837	-2.25
1971	41.3401	-6.21
1989	37.9776	-13.84

- 1970, 1971 and 1989 within SFWMM POR (1965-2000)

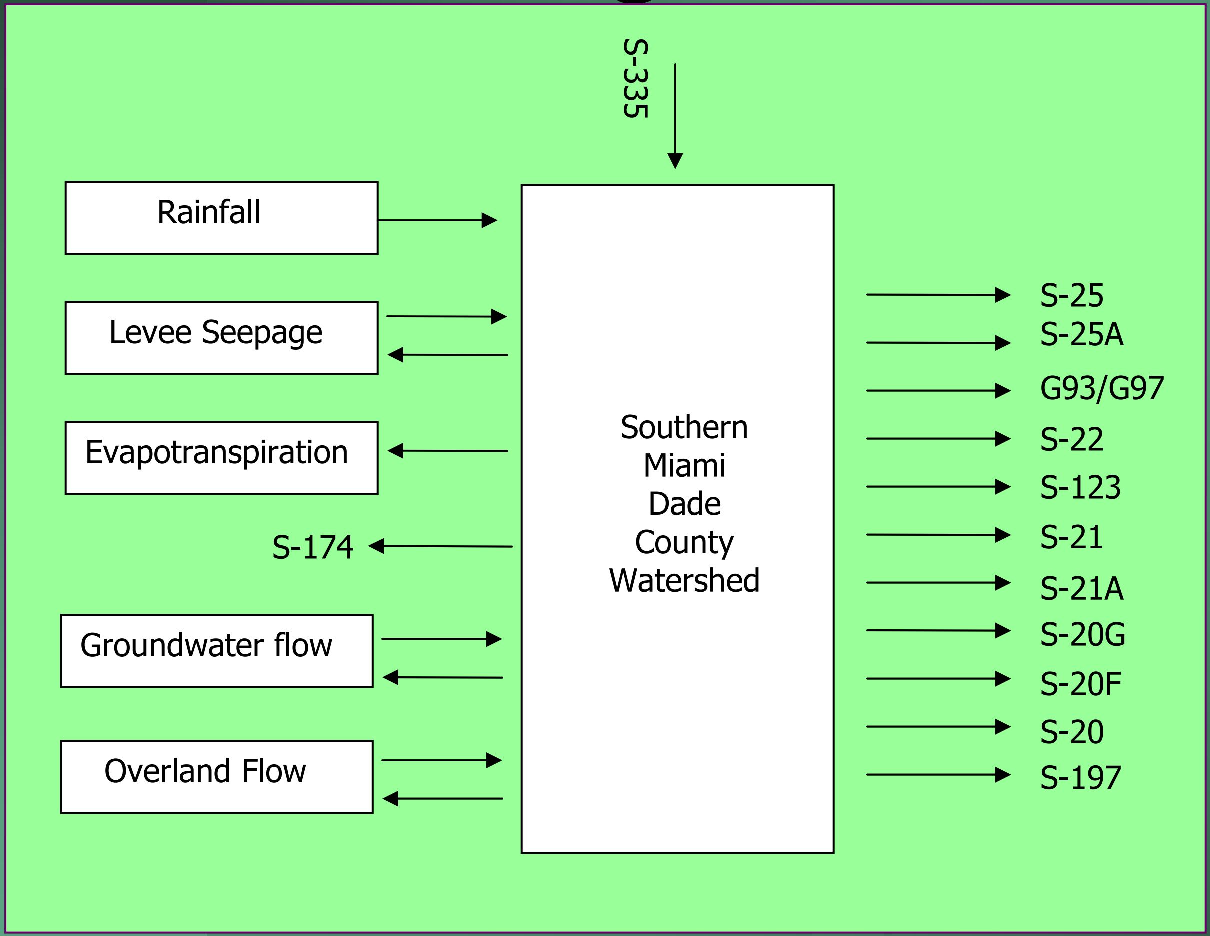
Use of SFWMM to Approximate Hydrologic Conditions

- Hydrologic “normal” year = average of all 36 years (1965-2000) using 2000 infrastructure, ops., withdrawals, etc.
- Drought year = average of 1970, 1971 and 1989 using 2000 infrastructure, ops., withdrawals, etc.
- Average is preferred due to variability among years



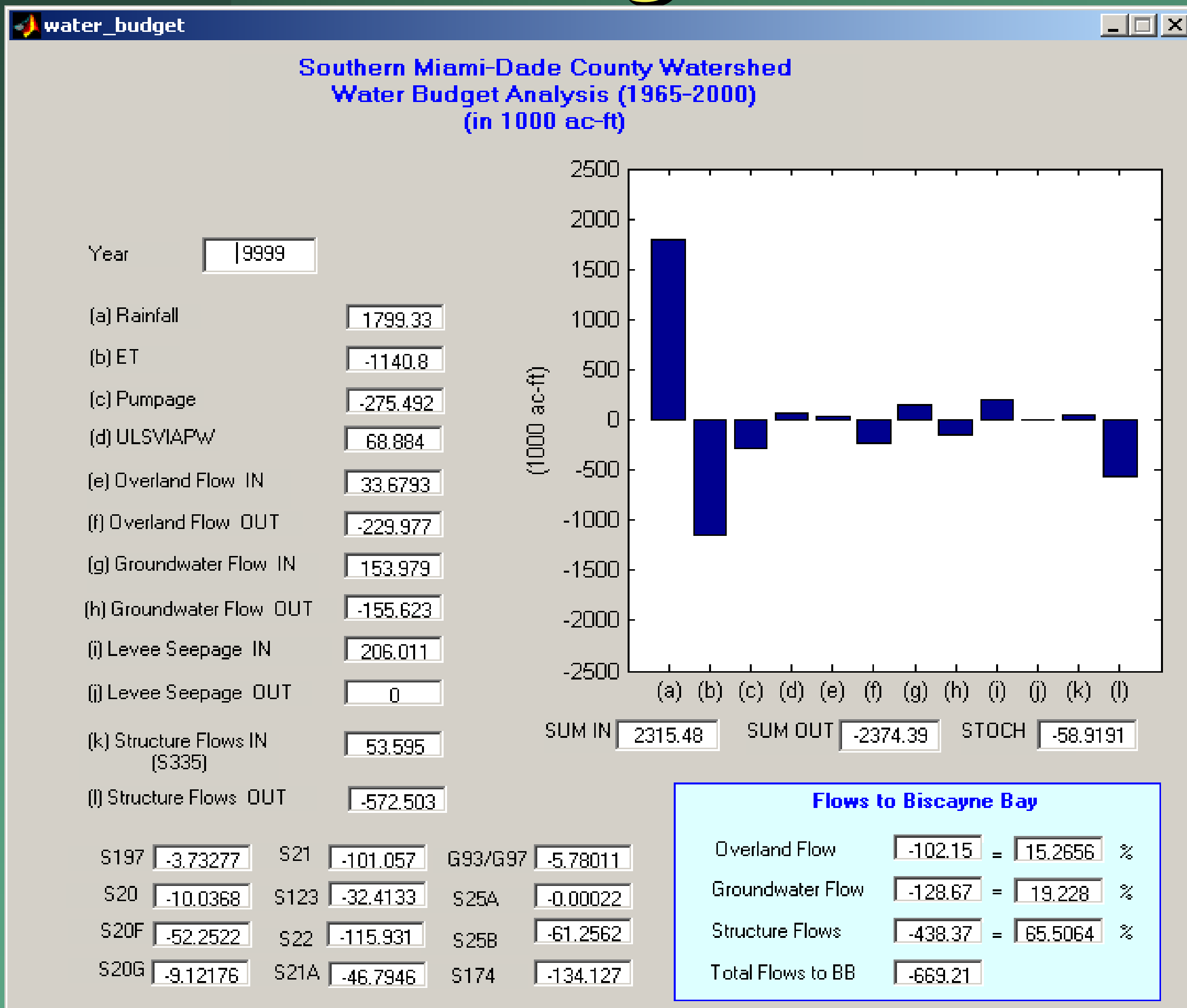
- Daily rainfall is variable
- Daily rainfall during drought can be > normal
- Overall drought rainfall < normal

Water Budget Schematic

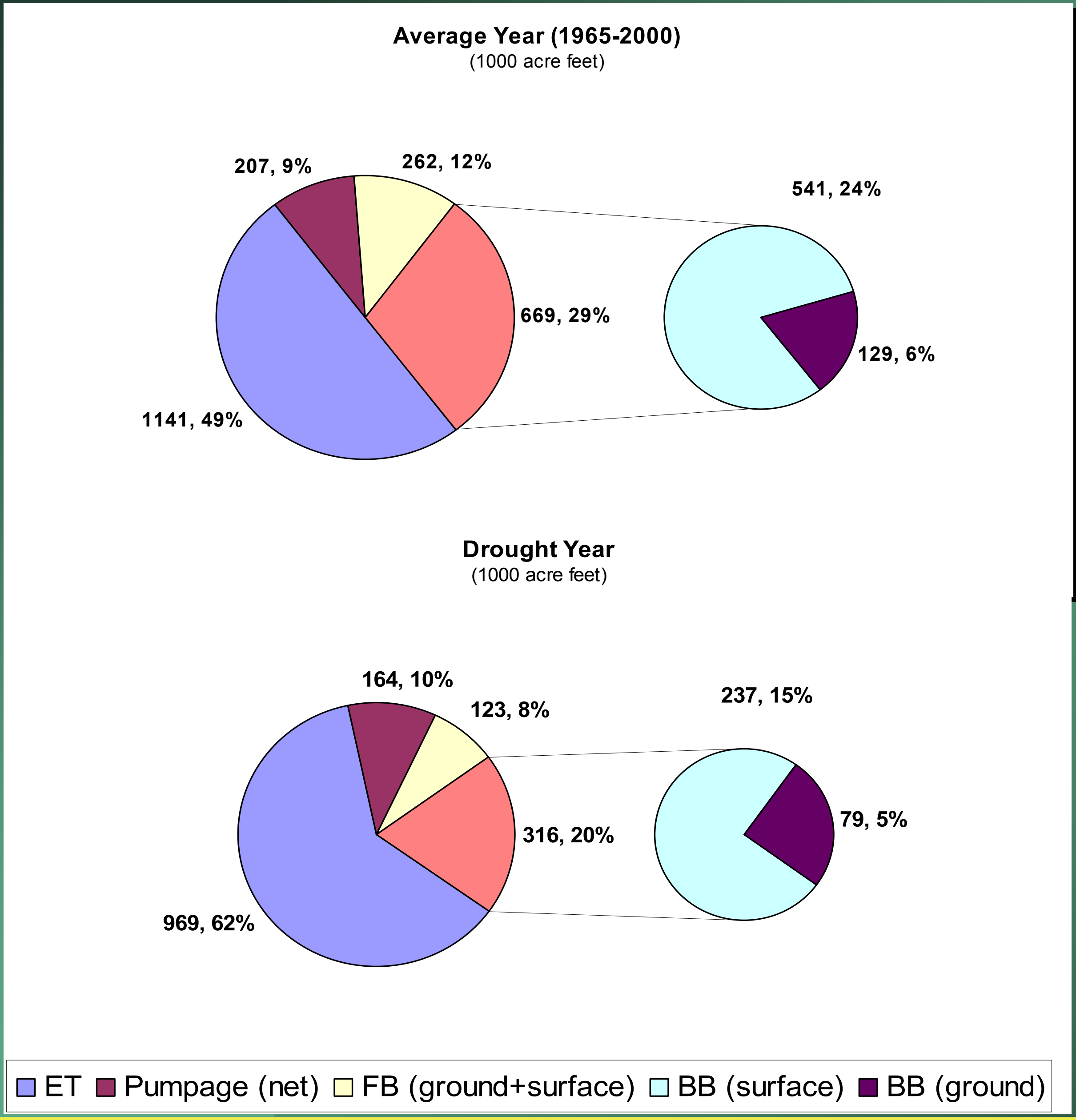


- **Water inputs and outputs used from SFWMM Base 1**

Water Budget

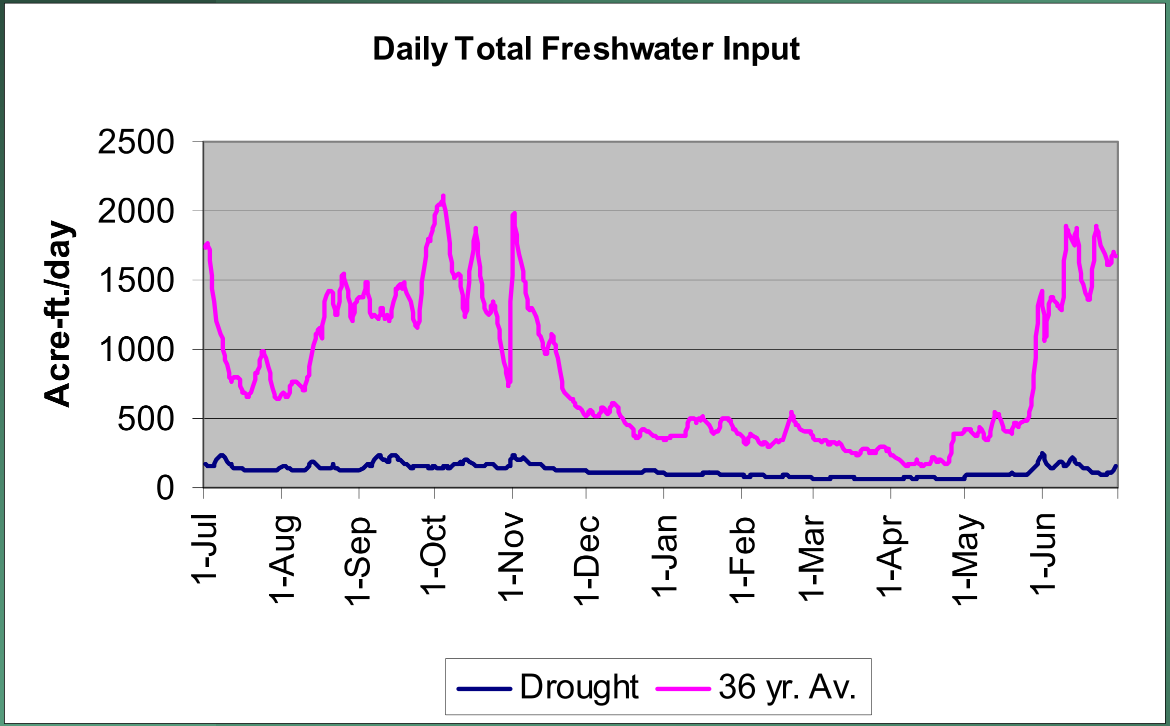


- Inputs and outputs quantified



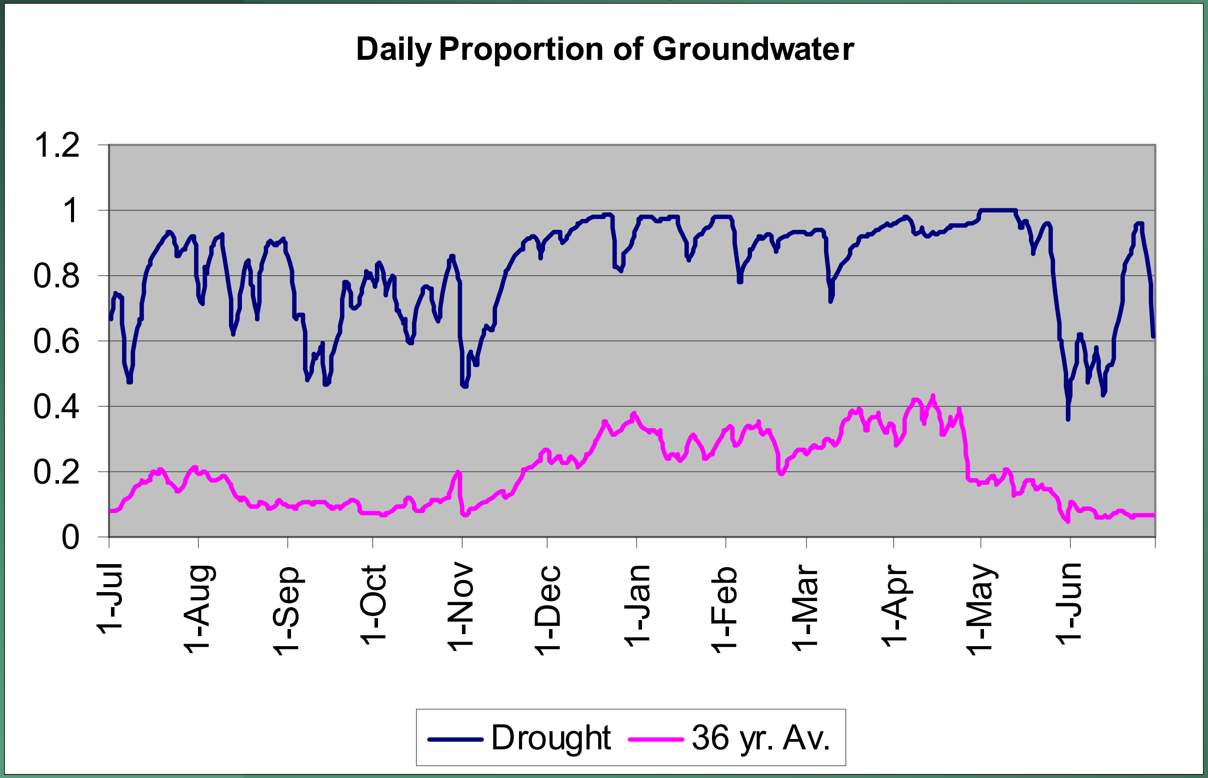
- **Largest output (loss)=ET**
- **Both quantity and proportion of water to Bay decreases during drought (~53%, ~9%)**
- **Proportion of groundwater greater in drought**

Water Budget



- Total freshwater into SC Bay much greater during normal year
- Largest difference occurs during wet season

Water Budget



- The proportion of groundwater to surface water to the Bay is greater during a drought.
- Most of the inflow is groundwater during a drought dry season.

South Central Biscayne Bay

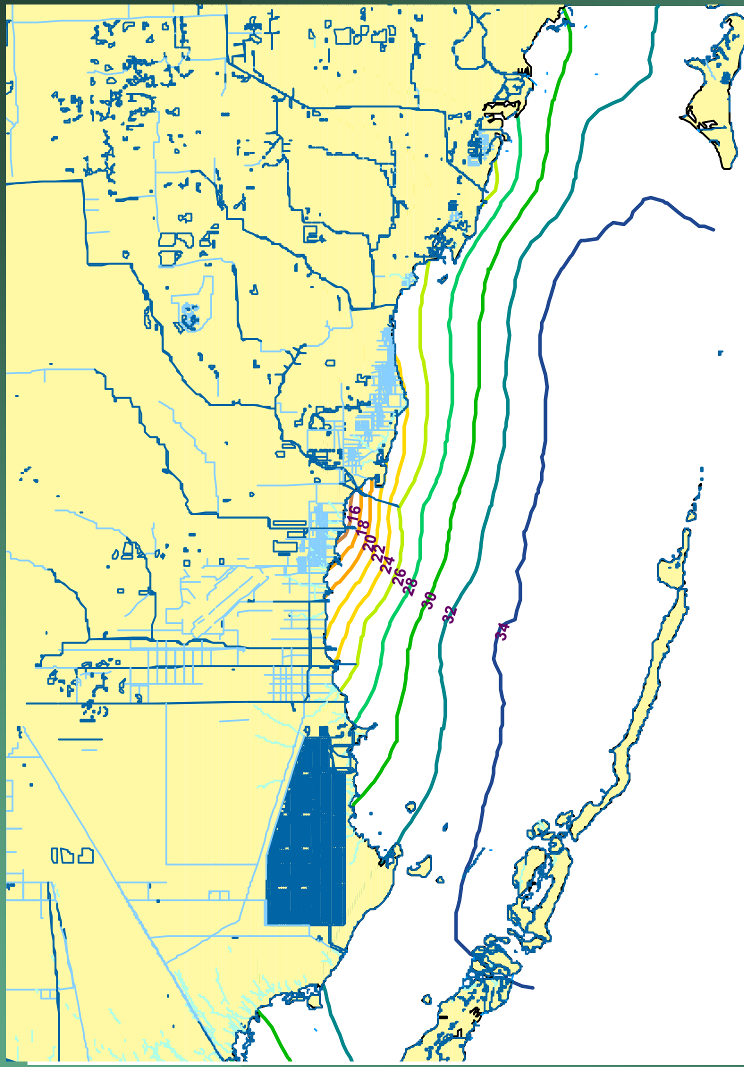
Salinity

Monthly Salinity Monitoring Stations (1993-2001)

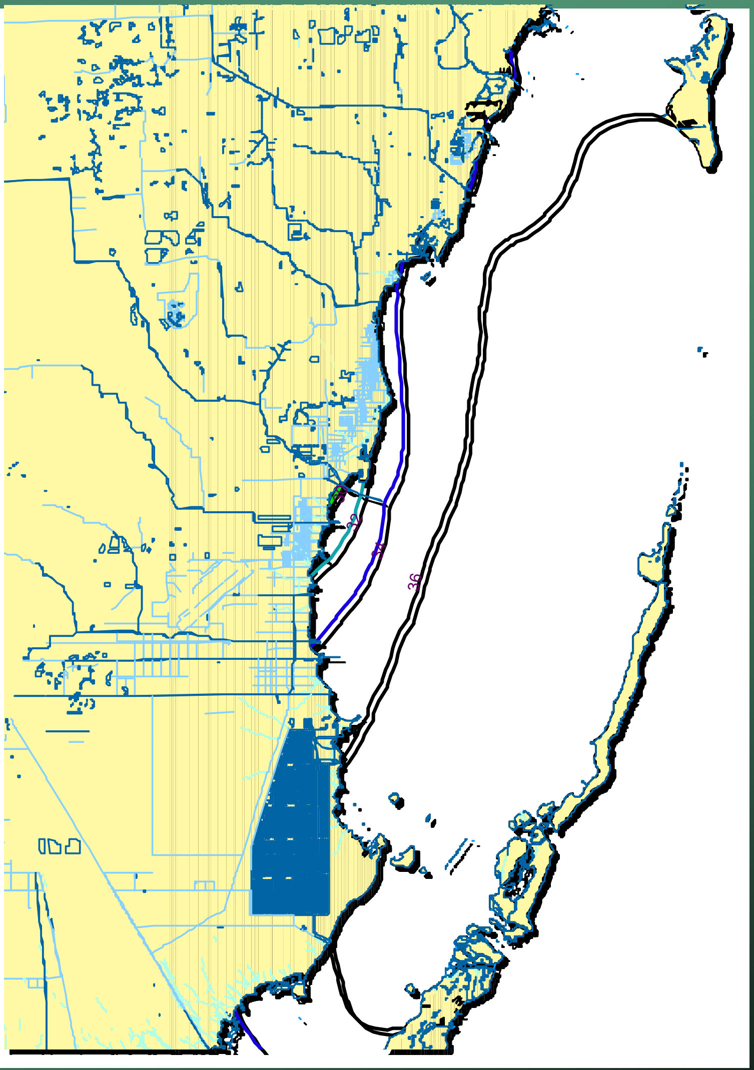
DERM

FIU

September Isohalines (15-35 ppt)



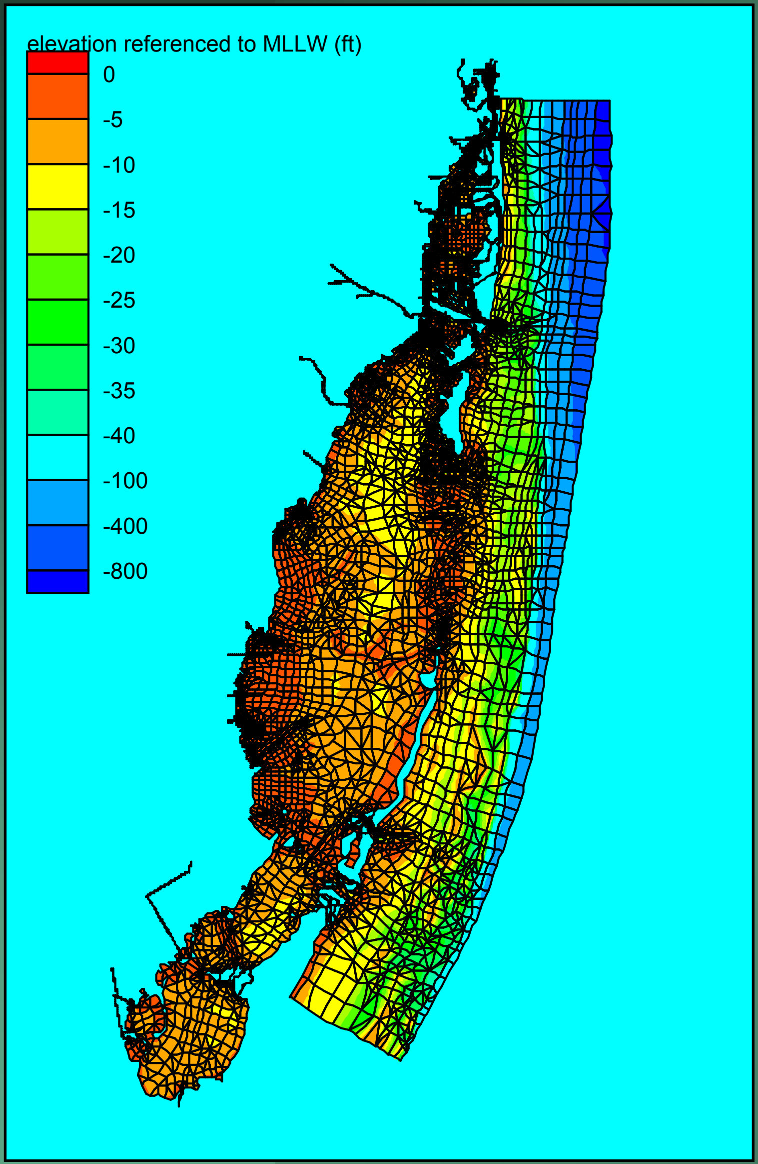
May Isohalines (30-37 ppt)



TABS-MDS Model

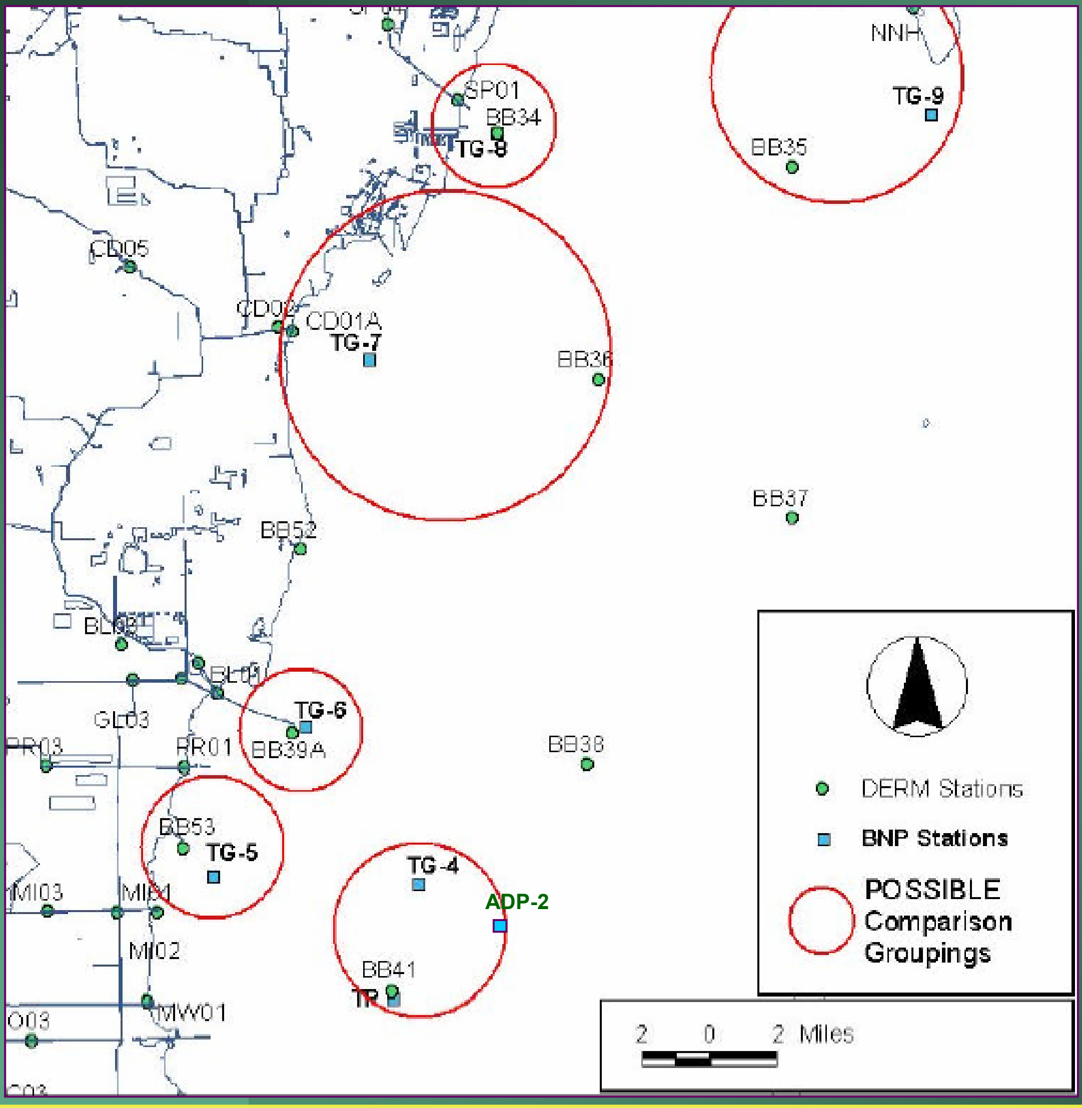
- Finite element, hydrodynamic model
- Based on RMA10, Dr. Ian King of Resource Management Associates (King 1993)
- Advantages :
  - easy to handle complex geometries
  - easy to incorporate different materials types
  - easy to handle complex boundary conditions
- Both unstructured and implicit
- GUI: Surface Water Modeling System (SMS)
- Easy to incorporate different model parameters

TABS-MDS Simulation Model



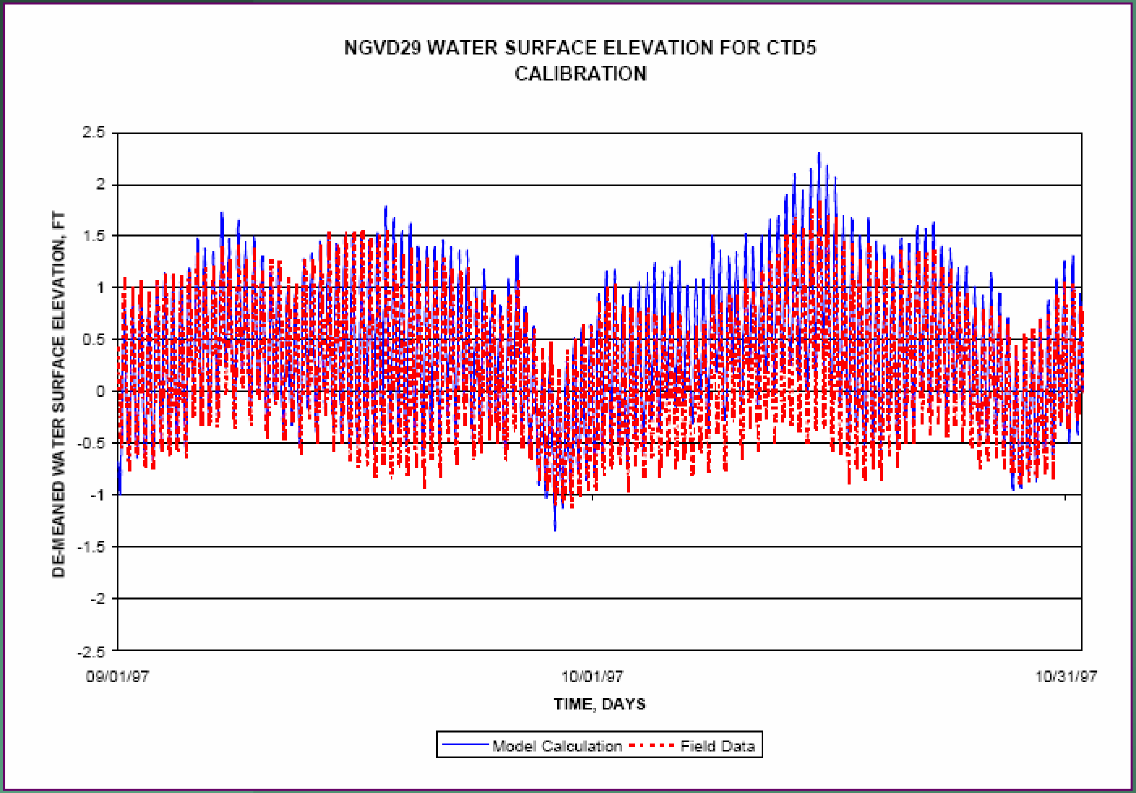
- U.S. Army Corps of Engineers CHL
- Mesh covers entire Bay
- Set it up for scenarios in southern area

TABS-MDS Simulation Model Development



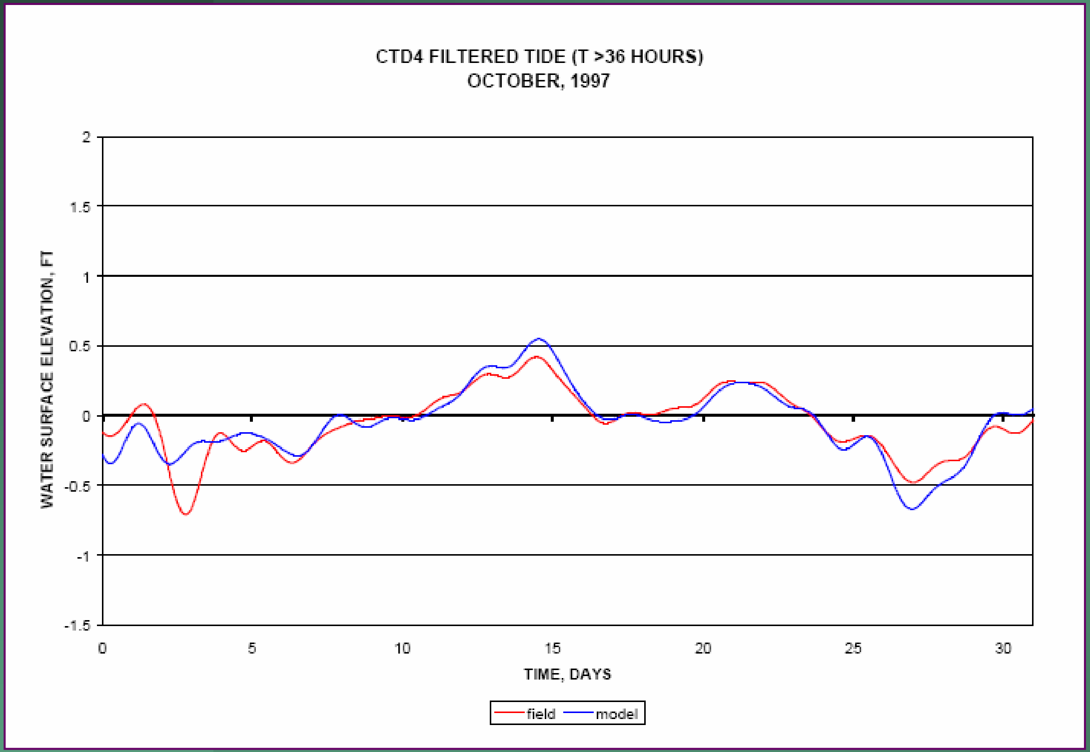
- Model was calibrated against physical data collected in the Bay

TABS-MDS Simulation Model



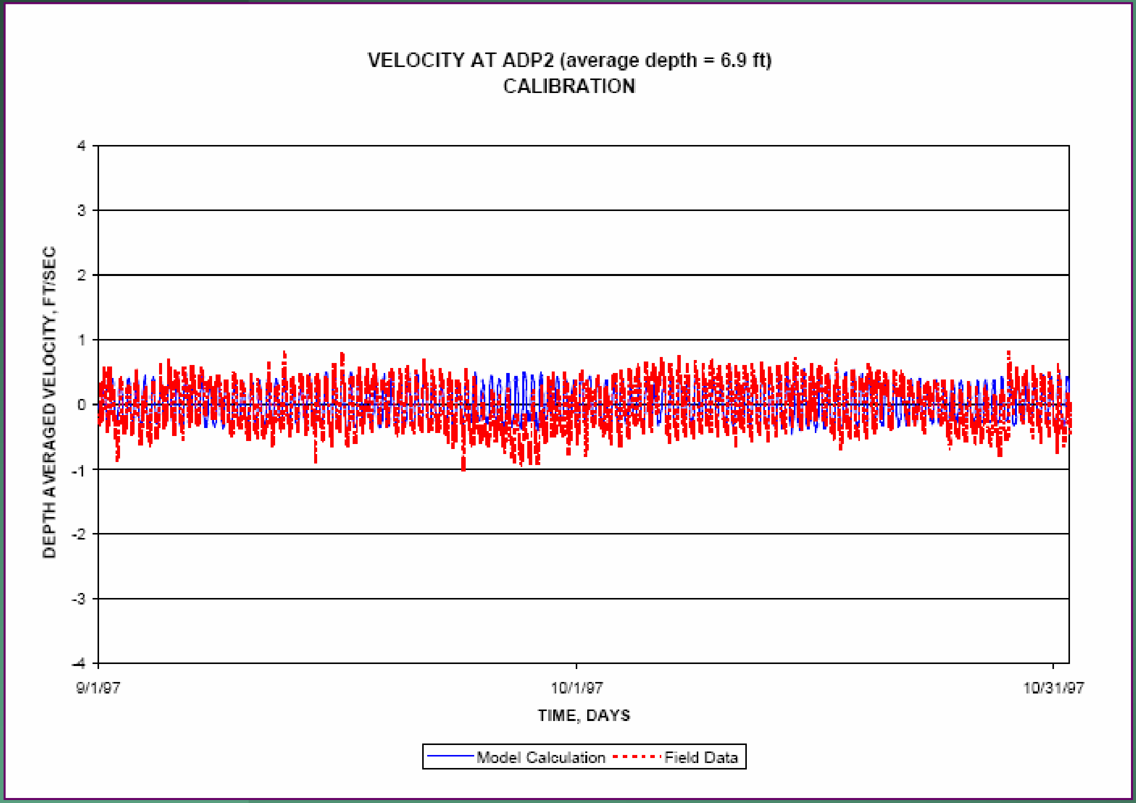
- Water elevation

TABS-MDS Simulation Model



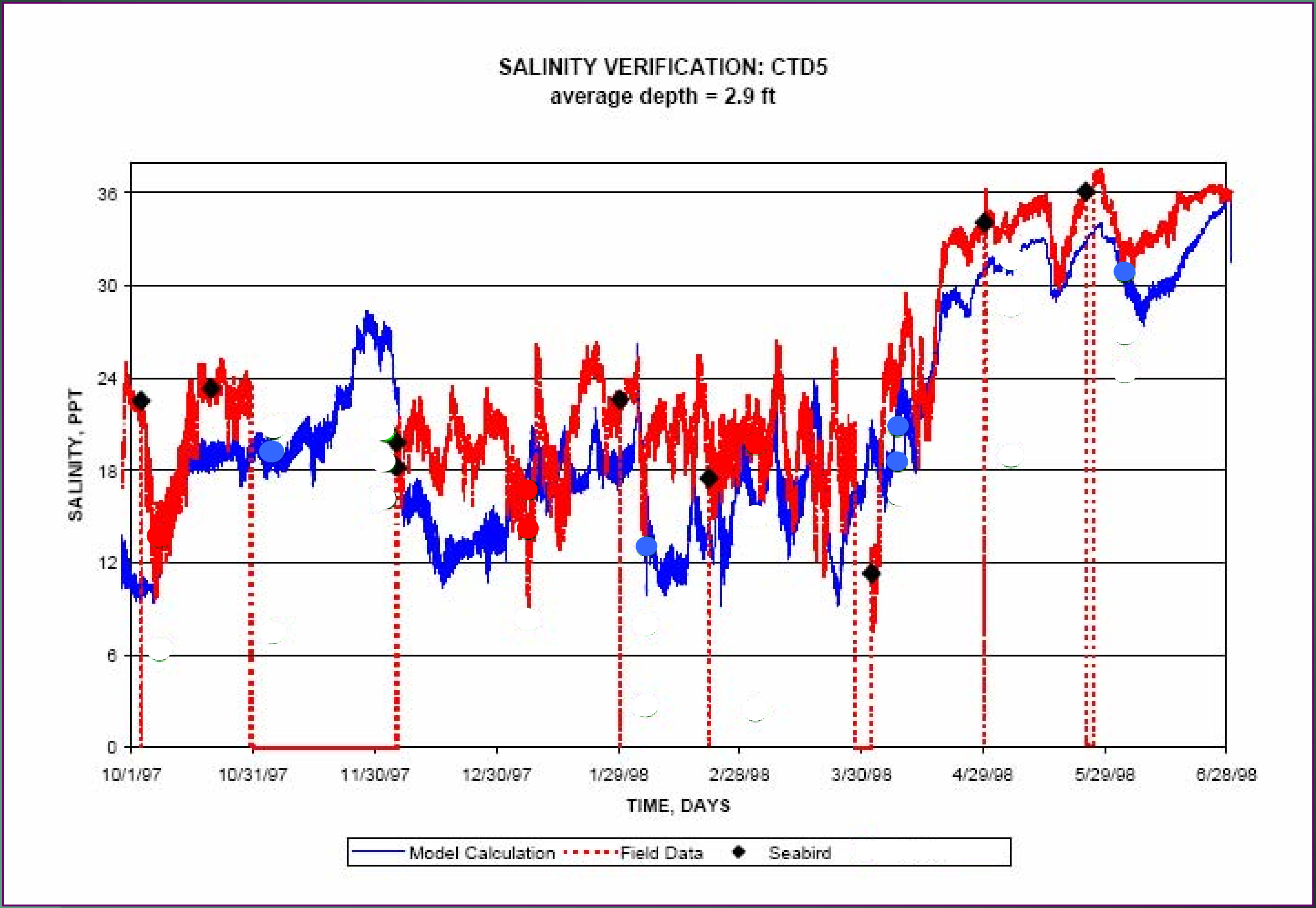
- Tide

TABS-MDS Simulation Model



- Currents

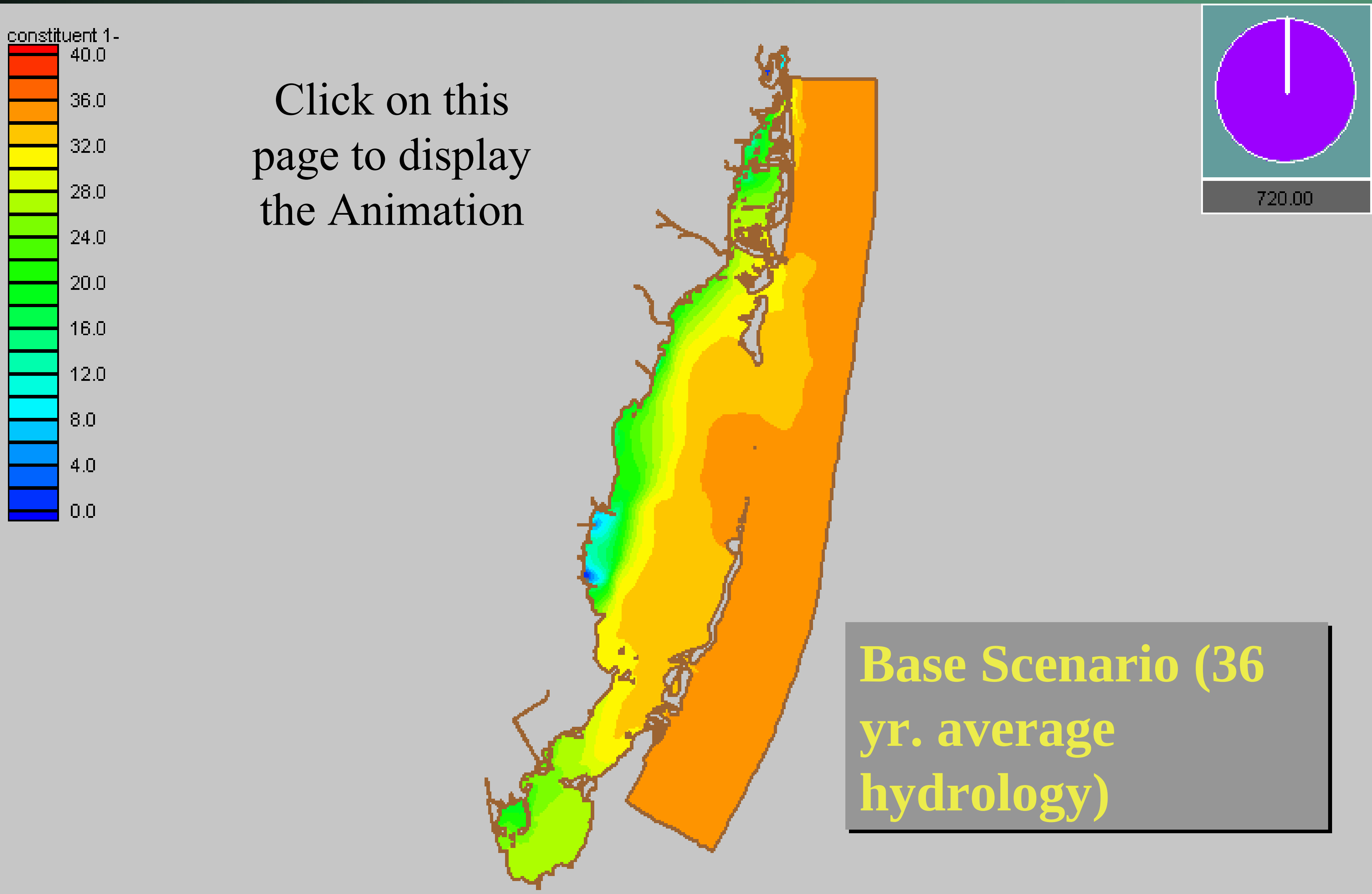
TABS-MDS Salinity Verification



The following two slides simulate the movement of the salinity gradient over one-year time periods. The first slide represents an average year based on the most recent 36 years of hydrologic record-keeping. The second slide represents the movement of the salinity gradient in an average drought year, as defined on page 36 of this presentation. Both simulations start on July 1 near the beginning of the wet season.

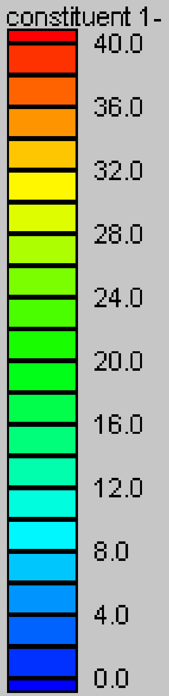
To view the next two animation slides you will need to have Quick Time on your computer. If you do not have Quick Time on your computer, please click on this link and it will take you out to the web site to download the Quick Time player.

When you get to the Quick Time site, please click on the second link and fill out the information at the bottom of screen. Then proceed to the next screen. Save the file to your hard drive. Then you will have to go to the file and install it. Then you will be ready to view the files.



Click on this page to display the Animation

Base Scenario (36 yr. average hydrology)



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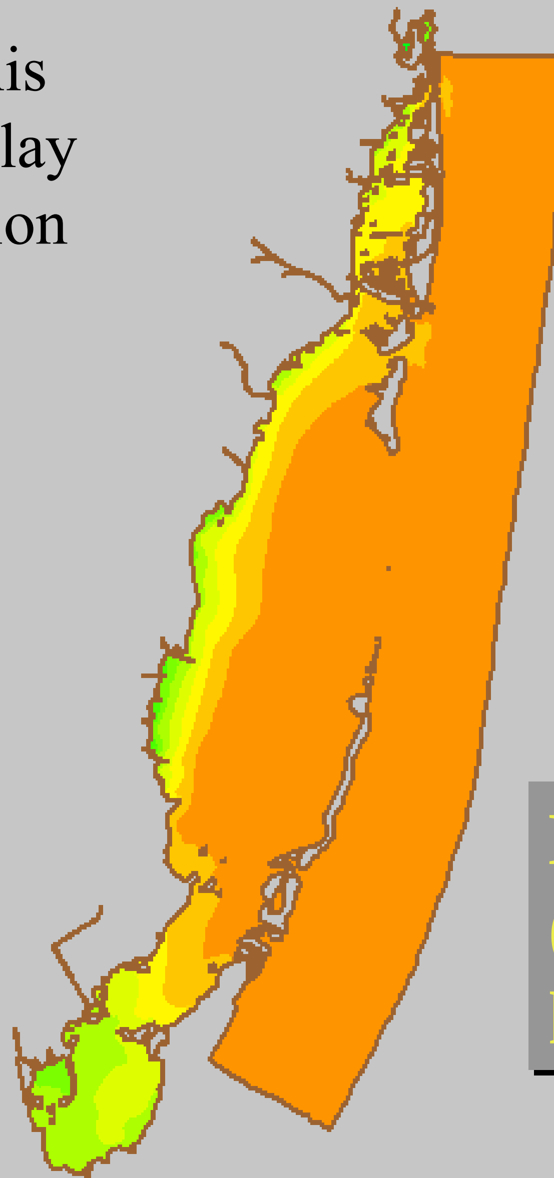
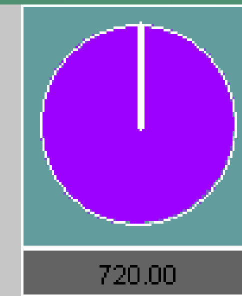
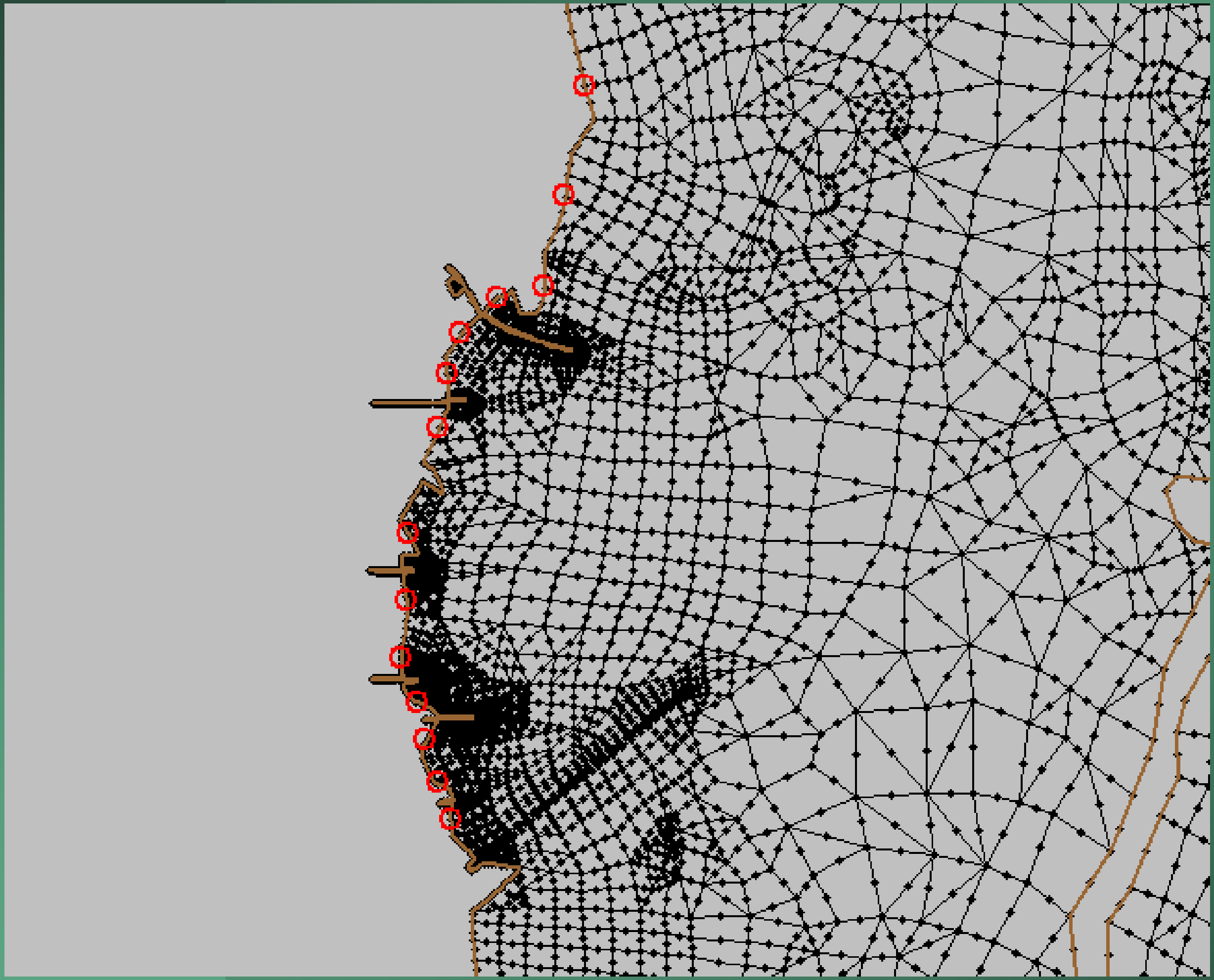




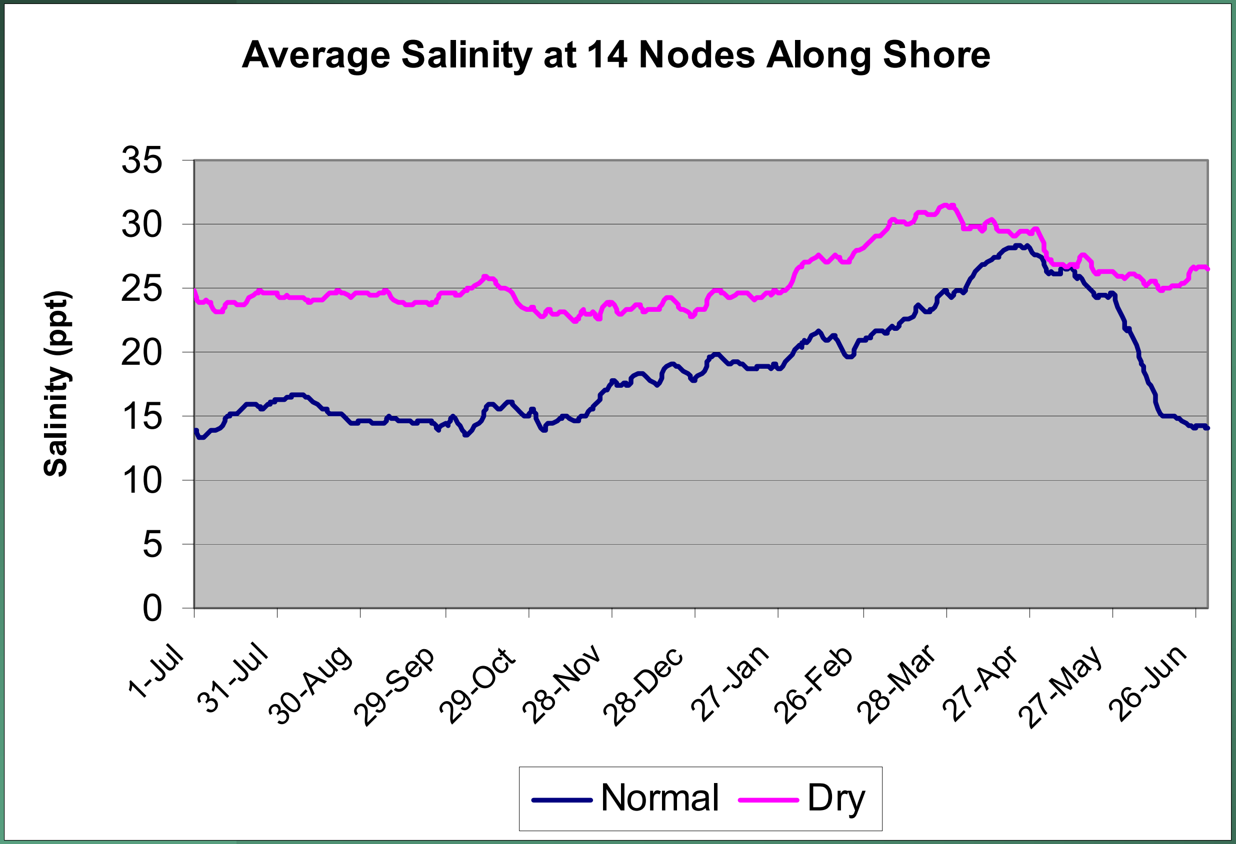
Drought Scenario (3 dry yr. average hydrology)

Normal and Dry Year Comparison



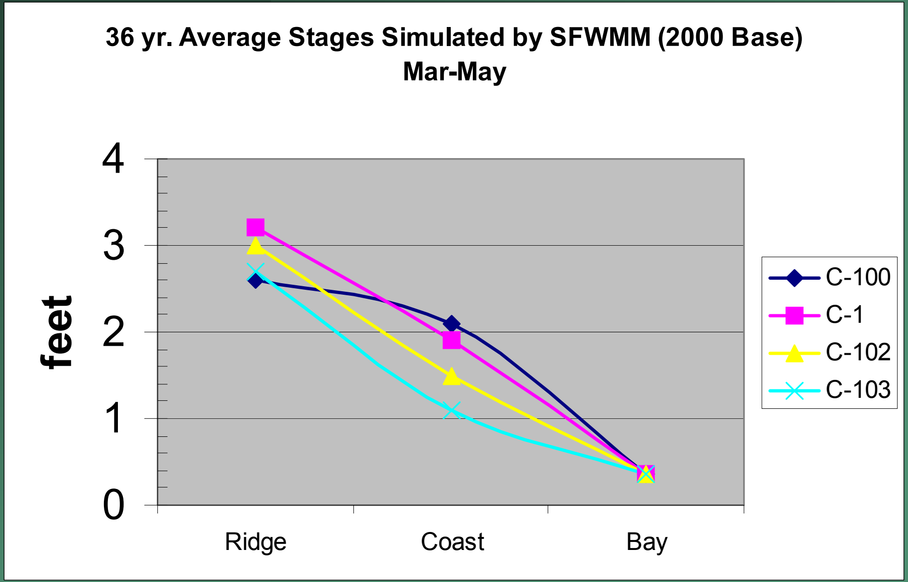
- Salinity at 14 nodes along shoreline

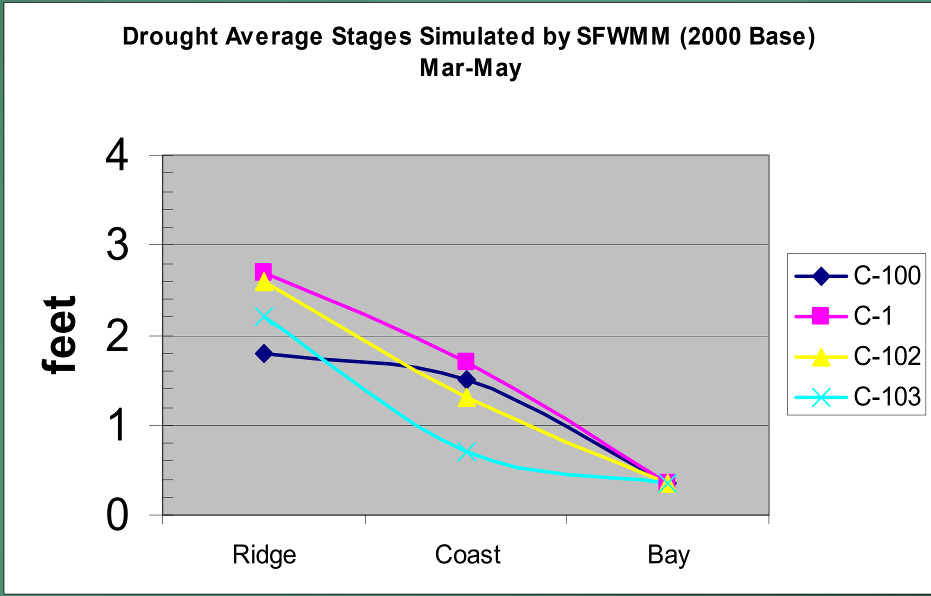
Normal and Dry Year Comparison



- Wet season salinity greatest difference
- Peak salinity normal~28 ppt
- Peak salinity dry~32 ppt
- Salinity shifts upward with reduced inflow

Dry Season (March-May) Stages





- **Normal dry season stages at coastal ridge: 2.6-3.2 ft.**
- **Drought dry season stages at coastal ridge: 1.8-2.6 ft.**
- **Groundwater slope drives input to Bay**

Modeling Tools Pros and Cons

- Models (SFWMM, TABS-MDS) calibrated and used for other applications
- Useful for comparing scenarios/ insight
- Groundwater flux, groundwater salinity somewhat crude
- Assumptions for variables like ET controversial
- Difficult to verify Bay salinity (lack of data)
- Both continue to be improved
- Verification data being collected

Some Observations About South Central Biscayne Bay Hydrology, Salinity and Ecology

- Models (SFWMM, TABS-MDS) indicate freshwater inputs persist up to a 1-in-10 year drought.
- Freshwater inputs are small during the dry season of a 1-in-10 year drought.
- The existing regime supports a wide variety of important species dependent on freshwater inputs.